Naval Research Laboratory

Washington, DC 20375-5320

NRL/MR/7230--12-9404

Talisman-Saber 2009 Remote Sensing Experiment

Charles M. Bachmann
Robert A. Fusina
Marcos J. Montes
Rong-Rong Li
Carl Gross

Coastal and Ocean Remote Sensing Branch
Remote Sensing Division

C. Reid Nichols
John C. Fry

Marine Information Resources Corporation
Ellicott City, Maryland

Chris Parrish
Jon Sellars
Stephen White

National Oceanic and Atmospheric Administration
Silver Spring, Maryland

Chris Jones
Krista Lee

Naval Postgraduate School
Monterey, California

March 30, 2012

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
30-03-2012	Memorandum Report	May 2009 – June 2010

4. TITLE AND SUBTITLE

Talisman-Saber 2009 Remote Sensing Experiment

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Charles M. Bachmann, Robert A. Fusina, Marcos J. Montes, Rong-Rong Li, Carl Gross, C. Reid Nichols,* John C. Fry,* Chris Parrish,† Jon Sellars,† Stephen White,† Chris Jones,‡ and Krista Lee‡

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

72-9824-09

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Research Laboratory, Code 7230
4555 Overlook Avenue, SW
Washington, DC 20375-5350

8. PERFORMING ORGANIZATION REPORT NUMBER

NRL/MR/7230--12-9404

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Office of Naval Research
One Liberty Center
875 North Randolph Street, Suite 1425
Arlington, VA 22203

10. SPONSOR / MONITOR'S ACRONYM(S)

ONR

11. SPONSOR / MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

*Marine Information Resources Corporation, Ellicott City, MD
†National Geodetic Survey, National Ocean Service, National Oceanic and Atmospheric Administration, Silver Spring, MD
‡ Space Systems Academic Group, Naval Postgraduate School, Monterey, CA

14. ABSTRACT

This report describes the data collected during one of a series of NRL remote sensing and calibration and validation (Cal/Val) campaigns, providing data and information for the development of models of coast types and their associated environmental factors for use in rapidly processing hyperspectral imagery (HSI) and generating shallow water bathymetric charts and trafficability maps. This report documents data that was collected during a remote sensing campaign that was conducted from May 18 to 29, 2009 at the Shoalwater Bay Training Area (SWBTA) located in Australia along a tropical stretch of the Queensland coast. Airborne collections from the HyMap™ sensor were used to build shallow water bathymetric charts and trafficability maps that were provided to military planners during Exercise Talisman-Saber 2009, which was conducted primarily in Australia and surrounding waters from July 13 to 16, 2009. This report details both the airborne HyMap imagery collected as well as the ground and water spectral and geotechnical data collected to calibrate and validate the products developed in support of the exercise.

15. SUBJECT TERMS

Hyperspectral
Trafficability
Bathymetry
Remote sensing

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Charles Bachmann
Unclassified Unlimited	Unclassified Unlimited	Unclassified Unlimited	UU	171	19b. TELEPHONE NUMBER *(include area code)* (202) 767-3398

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

Table of Contents

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

ADF	Australian Defence Force
AFRL	Air Force Research Laboratory
ARTEMIS	Advanced Responsive Tactically Effective Military Imaging Spectrometer
ASD	Analytical Spectral Devices
Cal/Val	Calibration/Validation
CBR	California Bearing Ratio
DCP	Dynamic Cone Pentrometer
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
GPS	Global Positioning System
GSD	Ground Sample Distance
HSI	Hyperspectral Imagery
HyMAP	Hyperspectral Mapper
in	inches
JPEG	Joint Photographic Experts Group
km	kilometer
LPA	Littoral Penetration Area
LPP	Littoral Penetration Point
LPS	Littoral Penetration Site
LWD	Light Weight Deflectometer
m	meter
μm	micrometer (micron)
MARFORPAC	Marine Corps Forces Pacific
MCIA	Marine Corps Intelligence Activity
MEC	MARFORPAC Experimentation Center
MEU	Marine Expeditionary Unit
NGA	National Geospatial Intelligence Agency
NRL	Naval Research Laboratory
nm	nanometers, nautical miles
ONR	Office of Naval Research
ORS	Operationally Responsive Space office
PACOM	Pacific Command
TACSAT	Tactical Satellite

EXECUTIVE SUMMARY

The Naval Research Laboratory (NRL) in collaboration with a number of other institutions (e.g., Office of Naval Research, National Oceanic and Atmospheric Administration, Australia Defence Force, HyVista Corporation Pty Ltd, and Marine Information Resources Corporation) has developed look up tables for estimating trafficability in littoral regions and the remote retrieval of bathymetry from hyperspectral imagery (HSI). Key instrumentation to collect requireddata for analysis includes airborne and space borne spectrometers, dynamic cone penetrometers, lightweight deflectometers, sediment corers, field spectrometers, underwater spectrometers, and handheld sonar. It should be noted that expeditionary airfield technicians of Marine Wing Support Squadrons use dynamic cone penetrometers to determine whether or not terrain is favorable for installation of landing pads and arresting gear.

To date the NRL-led trafficability research has been conducted at barrier island coasts found in the vicinity of Cape Charles, Virginia, along the Pearl River in Mississippi, and coral coasts along Kaneohe Bay on Oahu, Hawaii. The first of these experiments, held at the Virginia Coast Reserve Long Term Ecological Research (VCR LTER) site in 2007, provided the first demonstrations of the trafficability and shallow water bathymetry products (Bachmann, Nichols, et al, 2008; Bachmann, Montes, et al., 2008; Bachmann, Montes et al, 2010; Bachmann, Nichols et al, in press) and formed the basis of the analysis and products developed in the present study undertaken in Queensland, Australia.

This report documents data that was collected during a remote sensing campaign that was conducted from 18 – 29 May 2009 at the Shoalwater Bay Training Area (SWBTA) located in Australia along a tropical stretch of the Queensland coast, south of the Burdekin River and north of the Fitzroy River. This coast is somewhat protected from swell waves by the Great Barrier Reef, but is subject to approximately three tropical cyclones per year. Semidiurnal tidal ranges reach a maximum of more than nine meters in Broad Sound, but diminish to two meters in southern Queensland and three meters near Townsville to the north. Tidal ranges also decrease rapidly seaward and are on the order of six meters over the Great Barrier Reef. A number of the islands have fringing reefs. Saltpan, salt marsh, cheniers and mangroves are commonly found in this coastal region. Sandy beaches are attributed to sediment load from rivers.

Shoalwater Bay and surrounding lands are managed by the Australian Defence Force, for the purpose of military training exercises. Remotely sensed and cal/val data were collected in order to generate remote sensing products to support Exercise TALISMAN SABER 2009 (TS'09), one of Australia's largest multilateral military training exercises. The joint military exercise, undertaken biannually by the U.S. and Australia, included approximately 20 scientific experiments that improve crisis-action planning and contingency response, enhancing both nations' military capabilities to deal with regional contingencies and the Global War on Terrorism. Algorithms from this airborne remote sensing campaign can also be applied to space-borne sensors such asTactical Satellite-3/Advanced Responsive Tactically Effective Military Imaging Spectrometer (TACSAT-3/ARTEMIS), which was launched from Wallops Island, VA on May 19, 2009. Hallenborg and Nichols (2009) provided an assessment of the military utility of HSI, evaluating the utility of the NRL-led products derived from airborne HSI, during TS'09 to the Office of Operationally Responsive Space (ORS).

Airborne collections from the HyMap^{TM} sensor were used to build shallow water bathymetric charts and trafficability maps that were provided to military planners duringTS'09, which was conducted primarily in Australia and surrounding waters from 13-26 July 2009. The primary focus of TS'09 was to improve coalition force capabilities and the Joint Task Force certification of the III Marine Expeditionary Force (MEF) as a war fighting task organization under the United States Pacific Command (USPACOM). Researchers from NRL established an HSI exploitation cell at Camp Smith, Hawaii in order to interface with USPACOM. A liaison officer (LNO) representing NRL worked with militaryplanners from 31st Marine Expeditionary Unit (MEU) aboard the USS ESSEX. Researchers working in Hawaii and at-sea were provided with an opportunity to employ and validate hyperspectral imagery products such as trafficability maps with operational organizations such as III MEF and 31st MEU. Imagery and geotechnical collections from SWBTA were also used by a student from the Naval Post Graduate School to complete a thesis entitled, "Littoral Trafficability Prediction by Hyperspectral Imagers."

1 Introduction

This data report presents airborne hyperspectral imagery (HSI) and sea and ground truth observations made at the Shoalwater Bay Training Area (SWBTA) in central Queensland, Australia during May 2009 as part of Exercise TALISMAN SABER 2009 (TS'09). Goals and planning for TS'09 were defined in a science plan (see Bachmann Montes, et al., 2008, Bachmann, Nichols, et al, 2008; Bachmann, Montes, et al., 2010; Bachmann, Nichols, et al., in press). In summary, the Remote Sensing Division of the Naval Research Laboratory (NRL) participated in TS'09 to investigate the feasibility of supporting military planners by extracting shallow water bathymetry and characterizing bearing strength and shear of the foreshore from HSI. This data report highlights elements of the science plan and presents a description of the field program, instrumentation, and data collections. It is an overview of the various data types collected during the experiment, through summary plots and statistics, spectra, and imagery. This data report is intended to help transition partners from organizations such as the Naval Oceanographic Office (NAVOCEANO) and Marine Corps Intelligence Activity (MCIA) understand archived data and information as well as the TS'09 geodatabase. Example summary plots and statistics will also facilitate browsing the geodatabase. A formal NRL technical report describing remote sensing products developed by the NRL team will build upon this NRL Memorandum Report describing TS'09 collected data.

Numerous authors (Bachmann, Montes et al., 2008, Bachmann, Nichols, et al., 2008; Bachmann, Montes et al., 2010; Bachmann, Nichols, et al., in press; Mobley 1994; and Mobley et al., 2005) have discussed the use of HSI for the classification of coastal types and the estimation of shallow water depths. NRL's approach to coastal classification is an adaptation of Francis Shepard's work (see Nichols and Williams, 2008), where coastal subdivisions occur according to which specific agent, terrestrial or marine, has the greatest influence on coastal development. Coastal geodatabase development at NRL directly benefits the development of algorithms for processing HSI. Most importantly, the geodatabases facilitate the study of diverse coast types. Research efforts are currently focused on fine-tuning the measured relationships between spectra and environmental factors such as bearing capacity or water depth in order to support military decision-making. This work supports operational organizations such as the NAVOCEANO, MCIA, Marine Corps Forces Pacific, and U.S. Pacific Command, who have expressed interest in trafficability maps and shallow water bathymetry. TS'09 results are therefore being adapted to support the Marine Corps Planning Process. Imagery derived products will aid military planners to report factors such as shallow water bathymetry and trafficability. This information will improve the manner in which amphibious planners determine the capability of vehicles to transit the beach and pass through beach exits. Innovative new products developed by NRL, e.g., those demonstrated during the execution phase of TS'09, may also be added to the geodatabase by users.

Leading up to TS'09, several white papers, proposals, programmatic presentations and results from a remote sensing campaign in Hawaii were provided to various Navy and Marine Corps proponents regarding the Naval Research Laboratory's research thrusts and methodologies that advance the science behind coastal classifications. The final planning brief for TS'09 to MARFORPAC staff and selected others from the PACOM staff occurred on February 6, 2009 at Camp Smith. TS'09 exercise planners decided that NRL would provide a HSI exploitation cell to Camp Smith and would have a liaison officer aboard the USS ESSEX to help integrate HSI as a tool to support military decision making. During the execution phase of TS'09, airborne HSI

Manuscript approved September 22, 2010.

from HyMAP (www.hyvista.com) was used to develop trafficability and shallow water bathymetry products, and these products were delivered to operational staff involved in amphibious planning during the execution phase of TS'09. Following the execution phase of TS'09, NRL's research activities in estimating shallow water bathymetry and developing trafficability maps are continuing with ARTEMIS imagery, since it was not readily available during the execution phase of TS'09 in July 2009.

2 Field Experiment

The calibration and validation (Cal/Val) phase for TS'09 was carried out from 18-29 May at SWBTA in central Queensland, Australia and consisted of an airborne survey and the collection of ground and sea-truth data. The field Cal/Val team used laboratory space at Sam Hill for sample processing at SWBTA. Data collections included meteorological measurements in order to improve atmospheric correction of the measured spectral radiance. Atmospheric correction is the removal of effects that result from scattering and absorption in the atmosphere. Equipment failures such as a malfunctioning underwater spectrometer resulted in reduced data collection than what was originally planned in the science plan; however a large body of data was collected relating *in situ* geotechnical and oceanographic measurements to spectral reflectance above the water column and on land from substrates and vegetation. This calibration and validation data was later used to retrieve products from hyperspectral imagery and assess accuracy.

The geography of the SWBTA is provided in Figure 1. This area is used for Combined Joint Task Force Exercises, which combines blue water naval forces with air and land capabilities. The area has been well studied by environmental support scientists employed by the Australian Defence Force (ADF) to maintain and protect the SWBTA environment from degradation. Electronic resources, where complementary information for TS'09 can be found, are provided in Appendix A. Principal study sites at SWBTA included data collection efforts at Sabina Point and Freshwater Beach. The littorals around Shoalwater Bay are somewhat unusual with large parabolic sand dunes and scattered perched lakes and peat swamps. Spectral reflectance data representative of some of the vegetation found at SWBTA was also collected at the Lyon Arboretum and Foster Botanical Gardens in Hawaii in January and February 2009 and on site at SWBTA during the cal/val effort; this were primarily leaf optical reflectance measurement, and in some cases, a few representative canopy level reflectance spectra were measured, notably in mangrove regions of Shoalwater Bay.

2.1 Airborne Survey

Imagery was collected using the HyMap™ (www.hyvista.com) spectrometer mounted aboard a twin-engine aircraft during the period from 21-23 May 2009. HyMap provides 128 bands across the reflective solar wavelength region of 0.45 – 2.5 μm with contiguous spectral coverage (except in the atmospheric water vapor bands) and bandwidths between 15 – 20 nm. The spectral configuration of the HyMap sensor is depicted in Table 1.

Table 1. Spectral configuration of HyMap. Each of the spectral modules contains 32 bands for a total of 128 spectral bands

Module	Spectral Range	Bandwidth across module	Average spectral sampling interval
VIS	0.45 – 0.89 μm	15 – 16 nm	15 nm
NIR	0.89 – 1.35 μm	15 – 16 nm	15 nm
SWIR1	1.40 – 1.80 μm	15 – 16 nm	13 nm
SWIR2	1.95 – 2.48 μm	18 – 20 nm	17 nm
Additional details on the HyMap sensor may be accessed online at URL: http://www.hyvista.com.			

Flight lines (provided in Appendix B) were planned so that adjacent strips overlap, ensuring that complete ground cover was achieved over the TS'09 study area. Flight lines covered the study boxes that are provided in Figure 2. Since these boxes included areas that are covered by water, data was only collected when solar zenith angles were between 35-60° in order to minimize glint and flight paths were chosen such that the airborne platform flew into and out of the direction of the solar azimuth to further minimize glint from the water. Imagery was also acquired near both low and high tidal states since one objective was to verify bathymetry retrievals in the very shallow water limit of the inter-tidal zone. To validate bathymetry retrievals from the hyperspectral imagery acquired at high tide, post-processed kinematic GPS survey data was acquired in the inter-tidal zone. In addition, fathometer soundings were conducted throughout the shallow water areas to provide validation data beyond the inter-tidal zone. A water-level gauge was deployed during each day of field calibration and validation activities. This gauge, the GPS base station established by the team on site, and the rover post-processed kinematic GPS units provided the basis for direct comparison of depth retrievals against reference depths.

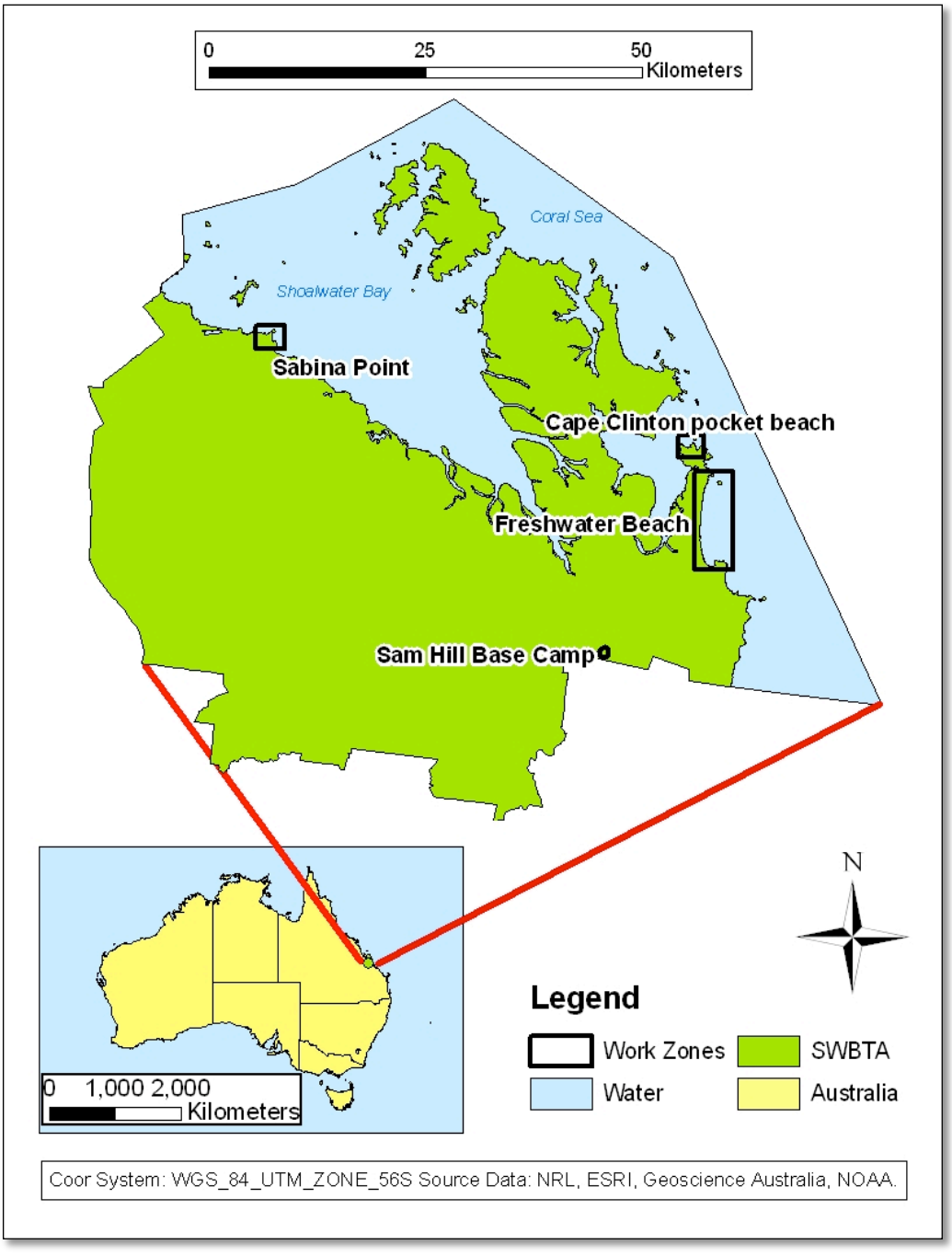


Figure 1. Geography of SWBTA. This coastal zone is dominated by various wetland types and includes fringing coral reefs, shallow open water with sea grass beds, rocky marine shores, beaches and sandbars, intertidal mudflats and sand flats, mangrove forests and melaleuca woodland, freshwater lagoons, and swamps and streams on elevated sand plains. The tidal flats and mangrove forests are particularly well developed owing to the macro-tidal range (i.e., 4m at Freshwater Beach and 7m at Sabina Point).

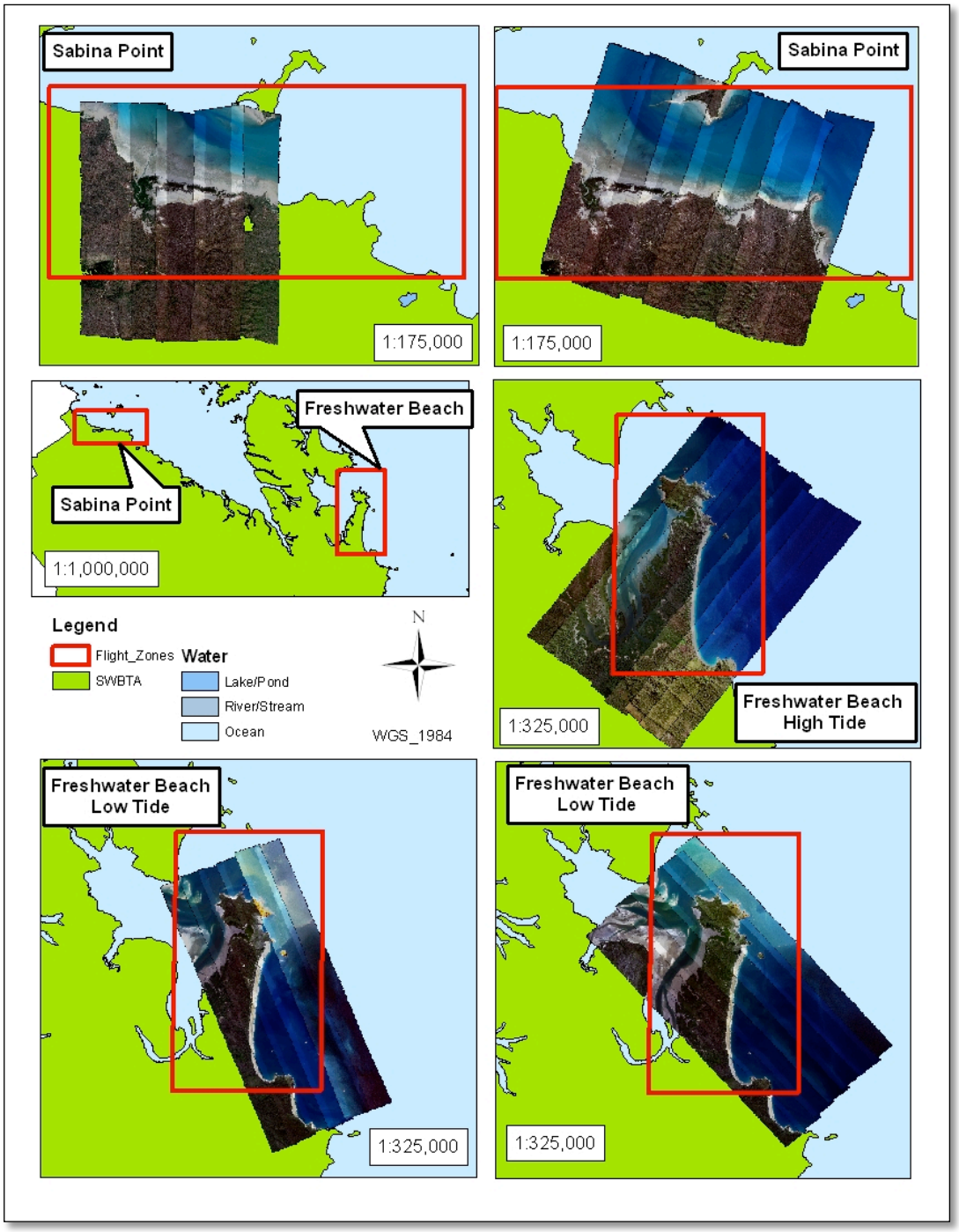


Figure 2. TS'09 Study Boxes. These views of SWBTA illustrate the location of primary and secondary study boxes as well as "quicklooks" of data acquired during the campaign. The northern box encompasses Sabina Point and surrounding beaches and inland tropical forest regions. The southern box includes Freshwater Beach, the main landing beach for amphibious exercises. Imagery was acquired at different stages of the tidal cycle, with particularly good coverage (low and high tide) at Freshwater Beach.

Each imagery strip is composed of successive scan lines acquired by the scanner along the flight line. The HyMap™ survey captured images of SWBTA in narrow contiguous wavelength channels or spectral bands, to create a data cube from which diagnostic spectra can be obtained from each pixel in the image. An example cube for the main landing beach is provided in Figure 3.

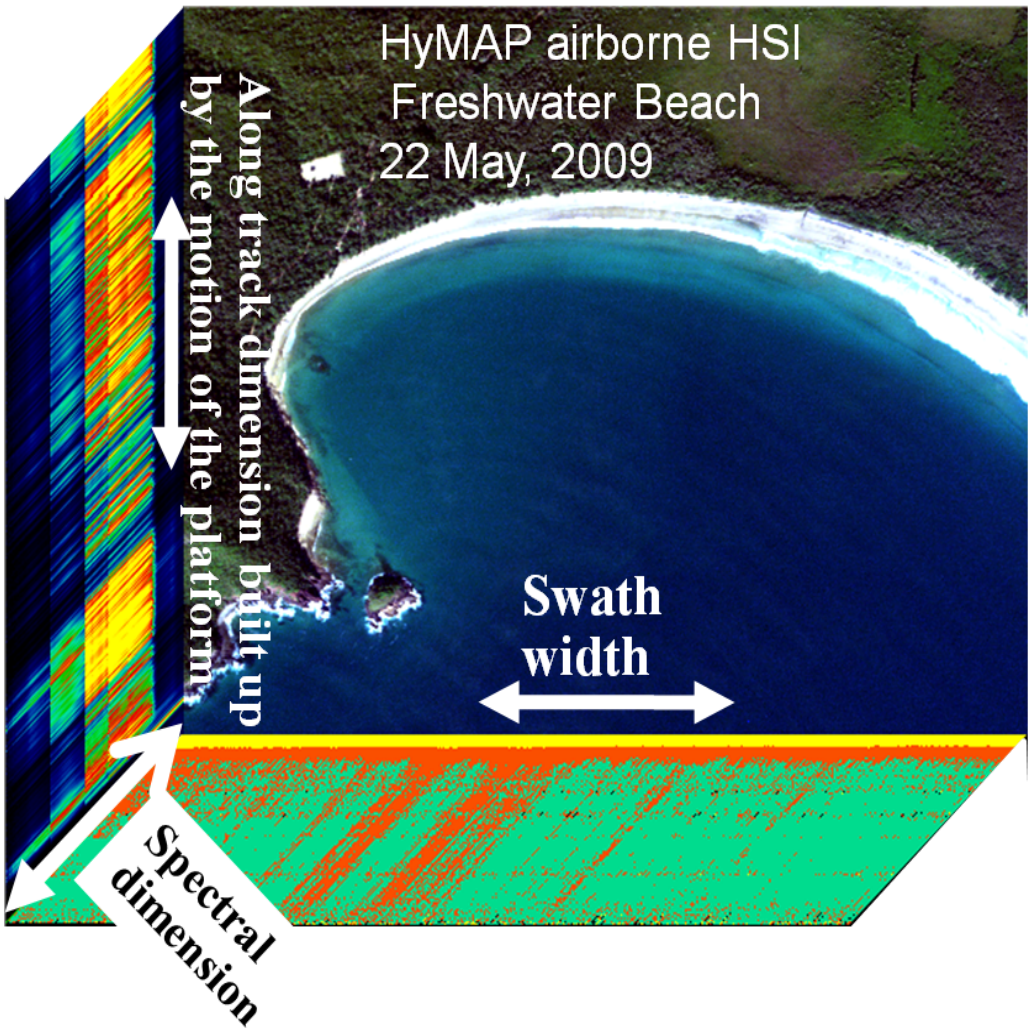


Figure 3. Hyperspectral Imagery Cube. Information from this imagery cube for Freshwater Beach was used to make trafficability maps and to retrieve bathymetry during TS'09. Cal/Val data were collected inland and along the coast to help characterize the Case 2 water areas.

Radiance values from each pixel are measured at many narrow, contiguous wavelength intervals. Such an image provides detailed spectral signatures for every pixel. These signatures often provide enough information to identify and quantify materials, even within a particular pixel. By removing atmospheric effects (atmospheric correction), data are then converted to images of the reflectance from the surface of the land or water across this large number of wavelengths. NRL uses collected hyperspectral images to locate and quantify different types of

vegetation, beach composition, soil moisture, and estimate bearing strength and depths in the near-shore region that are present within possible littoral penetration areas.

Meteorological and oceanographic data were collected to support tasks relevant to atmospheric correction and modeling the transfer of radiant energy across the air-sea interface. Since radiative transfer across wind-blown water surfaces is more complex and difficult to describe quantitatively than transfer within the water column, these environmental observations are imperative for follow-on numerical modeling tasks. Meteorological values displayed in Table 2 were used in TAFKAA (Montes, Gao, and Davis, 2004) and HYDROLIGHT (Mobley and Sundman, 2000). Refinement in imagery processing results in improved bathymetric retrievals and estimates of soil properties such as bearing strength. A complete listing of available imagery and weather data from Sam Hill at SWBTA is provided in Appendix C.

Table 2. Selected meterological values. Parameters such as air temperature, wind speed (ff), wind direction (dd) were collected for tasks such as atmospheric correction and modeling radiative transfer.

Day	Temp (ºC)		Max Wind Gust (m/s)			0900				1500			
	min	Max	dd	ff	time	Temp (ºC)	Wind (m/s)		Pres (mb)	Temp (ºC)	Wind (m/s)		Pres (mb)
							dd	ff			dd	ff	
21	9.6	25.1	WSW	6.1	1908	17.9	SSW	1.1	1010	23.7	WNW	1.7	1007
22	8.6	24.2	SE	5.6	1210	17.5	W	2.5	1011	22	S	1.9	1007
23	7.9	25.4	W	6.7	1430	17.5	SSE	1.7	1012	25.1	SW	3.6	1008
Daily Weather Observations for Station 033308 sited at Samuel Hill, Queensland for May 2009.													

2.2 Calibration/Validation Data

Primary instrumentation to collect data required for trafficability analysis includes spectrometers, lightweight deflectometers, dynamic cone penetrometers, soil core samplers, drying oven, and sieves. The portable field spectrometers were used to collect field spectra in support of remote sensing image analysis from hyperspectral imaging sensors. The lightweight deflectometer (LWD) was used to measure the dynamic deflection modulus of the substrate, which provides an estimate of bearing strength. The LWD imparts a pulse by dropping a weight onto an accelerometer embedded in a base plate, which simulates the response of the surface to passage of vehicle traffic. The dynamic cone penetrometer (DCP) determines shear strength by measuring the kinetic energy required to push a probe through the soil. Soil sampling was also conducted and analyzed at a field station to determine soil moisture content as well as grain size

profile. Post-processed kinematic beach surveys in the intertidal zone and soundings in the near shore waters (with accompanying differential GPS positioning) were also undertaken as described above. The use of geotechnical instruments fostered the accurate characterization of SWBTA's sand and muddy littoral environments. NRL found the SWBTA littoral region was very different from previously studied coasts composed of coralline sands, plastic clays, combinations of clayey gravels and sands of lesser plasticity, and lean clays and silts.

2.3 Site Characterization

Shoalwater Bay is located on the central coast of Queensland, Australia, which is approximately 100 km north of the coastal town of Yeppoon and 628 km north northwest of the state capital, Brisbane. Shoalwater Bay is a closely studied environmental area that is habitat for endangered species such as dugong (*Dugong dugon*) and is part of the Great Barrier Reef Marine Park. The dugong is heavily dependent on sea grasses for subsistence and is thus restricted to habitats such as Shoalwater Bay and associated mangrove swamps. Sea grasses such as eelgrass (*Zostera capricorni*), strapweed (*Posidonia australis*), and paddleweed (*Halophila ovalis*) have varying spectral response, especially in the reflectance of these sea grasses growing in varying wetlands. Example sea grasses that may be found in Shoalwater Bay are listed in Table 3. This region, which includes the Warginburra Peninsula, is one of Queensland's tropical rainforests. It includes a narrow, coastal, high rainfall belt fringed and dissected by a range of eucalypt forests and woodlands, mangroves, and *Melaleuca* swamp communities.

Table 3. Shoalwater Bay sea grasses. Field-based spectral reflectance studies have been important in generating baseline data that optimizes the mapping of submerged aquatic vegetation (SAV), and has laid the groundwork for the monitoring of the physiological condition of SAV meadows by hyperspectral remote sensing.

Scientific Name	Common Name	Latitude	Longitude	Comment
Caulerpa mexicana	fern algae	22° 27.39 S	150° 34.52 E	Eastern Shoalwater Bay
Cymodocea serrulata	serrated ribbon sea grass	22° 25.2 S	150° 19.65 E	Sabina Point
		22° 14.09 S	150° 18.52 E	Collins Island
Halodule pinifolia	needle sea grass	22° 12.05 S	150° 5.85 E	Shoalwater Bay (NW)
Halophila decipiens	paddleweed	22° 34.91 S	150° 32.60 E	Georges Creek
		22° 32.07 S	150° 30.38 E	Island Head Creek
		22° 25.1 S	150° 19.65 E	South Sabina Point
		22° 12.05 S	150° 5.85 E	Between Stannage Bay and Broome Head
Halophila ovalis	paddleweed	22° 36.29 S	150° 36.36 E	Head Creek
		22° 34.43 S	150° 35.28 E	Head Creek

		22° 23.84 S	150° 17.27 E	North of Sabina Point
		22° 20.97 S	150° 19.73 E	Conner Island
		22° 15.16 S	150° 23.41 E	North of Sabina Point
		22° 26 S	150° 43 E	Pearl Bay
Halophila sp.	paddleweed	22° 19.43 S	150° 11.44 E	McDonald Point to Sabina Pt.
		22° 12.05 S	150° 5.85 E	Between Stannage Bay and Broome Head
		22° 12.05 S	150° 5.85 E	Shoalwater Bay
		22° 12 S	150° 6 E	Stannage Bay
		22° 11.96 S	150° 5.916 E	Bald Hill
		22° 10.5 S	150° 5 E	Stannage Bay
Halophila spinulosa	fern seagrass	22° 33.43 S	150° 35.34 E	Head Creek
		22° 31.48 S	150° 31.71 E	Middle Shoal
		22° 15.1 S	150° 19.65 E	South of Sabina Point
Halodule uninervis	narrow leaf seagrass	22° 23.27 S	150° 15.94 E	North of Sabina Point
		22° 26.6 S	150° 43.98 E	Pearl Bay
		22° 12.05 S	150° 5.85 E	Shoalwater Bay
Zostera capricorni	Eelgrass	22° 31.93 S	150° 30.64 E	Western Shoalwater Bay
		22° 30.01 S	150° 33.44 E	East Creek
		22° 23.84 S	150° 17.27 E	Shoalwater Bay (West)
		22° 22.60 S	150° 30.54 E	Triangular Round Rock
		22° 15.1 S	150° 19.65 E	Sabina Point
		22° 12 S	150° 6 E	South of Stannage Bay
Information adapted from Seagrass-Watch (see URL: http://www.seagrasswatch.org).				

Since 1966, the land surrounding Shoalwater Bay has been under the ownership of the Australian Defence Force, for the purpose of military training exercises. The SWBTA encompasses approximately 454,500 hectares (4,545 km²), which includes the Warginburra

Peninsula, the Torilla Peninsula east of the Stannage Bay Road, Townshend and Leicester Islands, and a sizable chunk of the Shoalwater Bay hinterland north of the village of Byfield. Townshend Island, which is located at the mouth of Shoalwater Bay, includes a target range and landing beach. On land, military access to SWBTA is through Raspberry Creek and Rossmoya Roads. Access through Stannage Bay Road has been closed to general military traffic since 1999. Access to SWBTA from the Coral Sea is usually via Freshwater Bay and Sea Hound Hard that is on the south arm of Port Clinton. Other nearby beaches include One Mile Beach, Nine Mile Beach, and Five Rocks Beach. There are some massive parabolic sand dunes found along the coast such as the "Orange Bowl" dunes at Nine Mile Beach. The southern half of Five Rocks Beach is adjacent to Byfield National Park and the northern half of the beach is adjacent to the SWBTA. The tidal range is high and approaches seven meters at the mouth of Shoalwater Bay and is in excess of five meters at Port Clinton, a natural harbor. These large tidal ranges have contributed to the development of extensive mud and sand flats and mangrove forests. The times of high and low water as well as predicted tidal amplitudes from 21 to 23 May 2009 at Port Clinton are provided in Table 4.

Table 4. Tide predictions for Port Clinton. Tide heights (Ht) are in meters above lowest astronomical tide**,** ***red for low water*** and **blue for high water.** Times stated are Australian Eastern Standard Time (24 hour clock).

21 May 09		22 May 09		23 May 09	
Time	Ht	Time	Ht	Time	Ht
0058	*1.27*	0149	*1.06*	0238	*0.87*
0657	3.52	0747	3.54	0834	3.54
1307	*0.81*	1359	*0.67*	1441	*0.58*
1936	3.92	2009	4.17	2104	4.35
Adapted from Australian Bureau of Meteorology. Available online at URL: http://www.bom.gov.au.					

Data collected during this survey focused on Sabina Point and Freshwater Beach. Sabina Point is characterized by a low swampy mangrove shore, intersected by several salt-water creeks, and sandy beaches that are fronted by extensive mud flats, which are inundated at about half flood, and extend offshore from approximately 500 m to 3 km. Freshwater Beach is a gently sloping 10 km long beach with a well developed fore-dune ridge. Beach sands tend to be composed of mainly well-sorted pale brown quartz sand. Wind-deposited sands have developed the fore-dune ridges, which consist of pale brown fine quartz sands with little if any soil development. Fore-dune ridges tend to be exposed to the prevailing southeast winds and are subject to erosion and blowout development during cyclones.

3. Project Archive

3.1 General Information

Remote sensing campaigns at NRL are of great importance since they are being conducted at various coastal sites and allow the collection of large scale (1:5,000) data. The archived datasets are crucial to generating useful relationships among California Bearing Ratio (CBR), a standard index of soil shear strength, and other fundamental material properties for soils, especially in selecting favorable littoral penetration points. CBR is derived from penetration tests that measure the pressure required to penetrate the soil. The USMC uses CBR to determine the load-bearing capacity of soils used for building roads and expeditionary airfields. Harder surfaces will have higher CBR ratings. In general, a CBR of 3 equates to tilled farmland, a CBR of 4.75 equates to turf or moist clay, while moist sand may have a CBR of 10. High quality crushed rock has a CBR over 80. Archiving this type of data from NRL's remote sensing campaigns complements existing databasing efforts such as the small scale (1:5,000,000) United Nations Food and Agriculture Organization's world soils map (see FAO-UNESCO 1974) and the medium scale (1:250,000) Soil and Terrain Database (see ISRIC 2004), and relating this and other associated geotechnical data to *in situ* spectral measurements and remote sensing data is the basis of NRL's approach to remote retrieval of soil bearing properties

3.2 Geodatabase

When developing a geographic database or "geodatabase" to archive the results of feature classification, it is important to include, at a minimum, the imagery that each feature was based on, and the associated feature class or vector file. Figure 4 explains how the

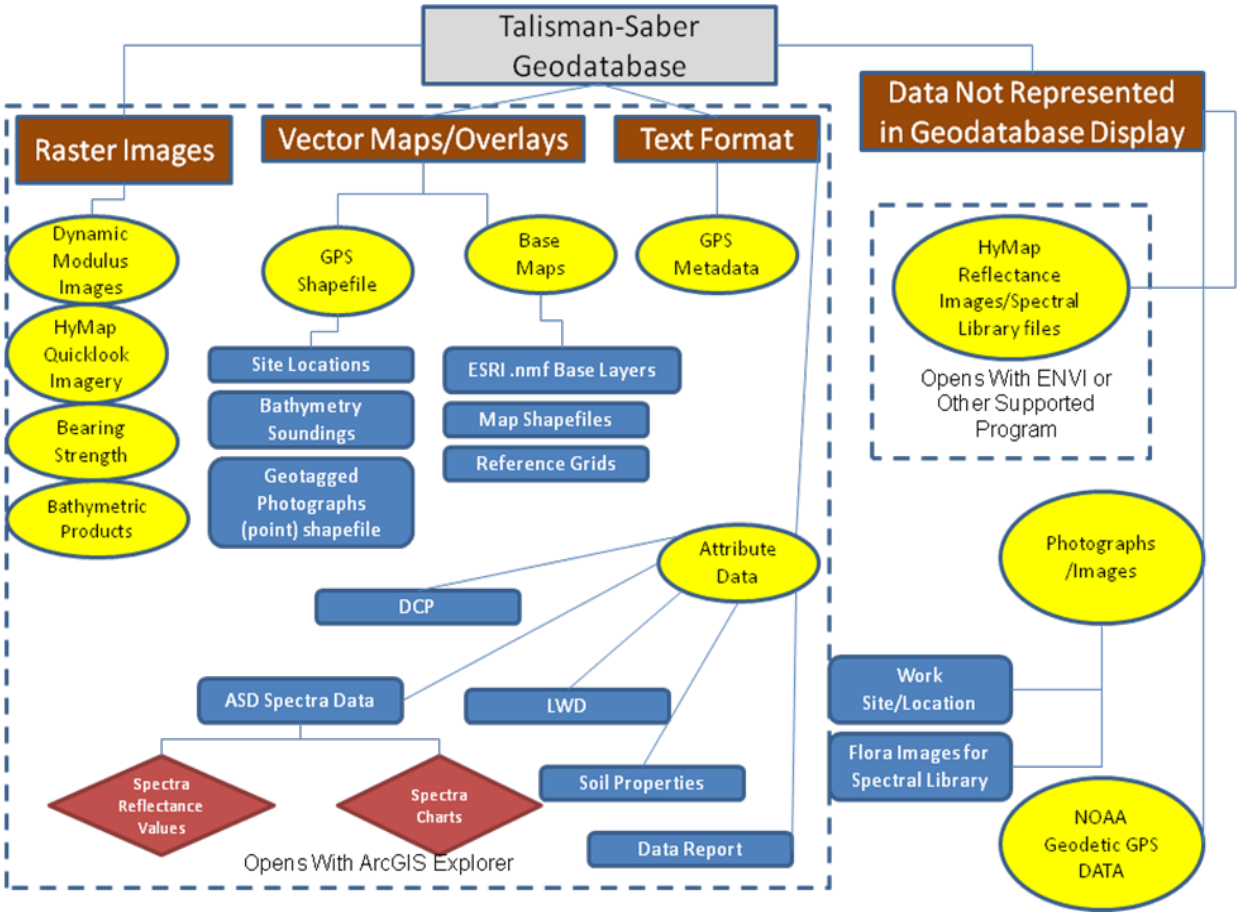


Figure 4. TS'09 geodatabase development framework. HyMap quicklooks and GPS Datasets are opened with ArcGIS Explorer. Attribute data is stored in Microsoft Excel files, Microsoft Word document files, or as JPEG Images. HyMAP reflectance images need to be opened with ITT's ENVI or another supported program.

Features and images of this project were organized into a file geodatabase, which was provided to users aboard the USS ESSEX during the execution phase of TALISMAN SABER'09 and has also been provided to NAVOCEANO on an external hard disk. When developing these geodatabases, we include selected intermediate files. Showing all the imagery analyses involved in creating the final result is helpful to those who want to repeat the same process for similar projects. Regardless of the number of files included, metadata is provided for each feature so others can understand how a particular file was produced and the proper way it should be interpreted.

The software packages used in the development of NRL CODE 7232 geodatabases are ESRI's ArcGIS Explorer and ESRI's ArcGIS suite. Both can be used to view the geodatabase,

but there are organizational differences in data structure between the two viewers. The primary software package to view the geodatabase would be ArcGIS, as it allows for analysis and interpretation capabilities much greater than ArcGIS Explorer. ArcGIS Explorer is a free Geographic Information System (GIS) software package based on ESRI's commercial ArcGIS product series. The software package facilitates the input of local data as well as data from ESRI. Shapefiles made in ArcGIS can be brought into the ArcGIS Explorer. ArcGIS users may find some compatibility issues with the ArcGIS Explorer, but in general, data created in ArcGIS can be brought into ArcGIS Explorer. Keyhole markup language (.kml) and keyhole markup language-zipped (.kmz) files made in Google Earth can be imported into ArcGIS Explorer.

ESRI's ArcGIS Explorer allows this GIS database to be applied by others that do not have access to ArcGIS. This allows for geodatabase developers at NRL to present data findings to potential operators in the field who do not have access to imagery analysis software. For example, the ArcGIS Explorer database was used aboard the USS ESSEX by a scientist from Space and Naval Warfare (SPAWAR) Systems Center – Pacific during TS'09. There are some limitations to ArcGIS Explorer, but, this software package allows for the development of databases with the use of Microsoft® Excel as the spreadsheet database. This software package is available for download (ESRI, 2009).

ArcGIS, which is a commercial product, allows for much better analysis of shapefiles than the freeware ArcGIS Explorer, as it enables selecting and differentiating attribute data and presenting the data through symbology. ArcGIS has the ability to gain much more information through the attribute data of shapefiles such as setting important regions with different colors. In ArcGIS Explorer, differentiating regions of a shapefile through analysis of the attribute table data is not possible. If a shapefile's attribute data is given symbological levels of different colors in ArcGIS, it can be exported as a kml file and imported in ArcGIS Explorer, but the resultant image will appear as a raster in the viewer and each polygon does not produce attribute data. Collected attribute data in ArcGIS is stored in spreadsheet and document form and can be accessed by using the identify tool and hyperlinking to the data.

Specific types of data (raster, vector, and text) included in the TS'09 geodatabase are as follows:

- **Imagery** - HyMap imagery was added into both GIS programs as well as the GPS shapefiles. HyMap reflectance files cannot be opened within the ArcGIS Explorer software. These files, which provide reflectance values at each wavelength, can be analyzed to relate the spectra that comprise the data to a variety of environmental types over the study area. Geotagged photographs for Sabina Point and Freshwater Beach are also included in the geodatabase.
- **Survey data** - Each of the Trimble differential GPS locations was processed and exported as a shapefile, depicting the point where data was captured.
- **Cal/Val data** - The GPS shapefiles highlight the location on the Earth's surface where instrument data were taken. The instrument data are stored as Microsoft Excel spreadsheets, JPEG images, or Word documents with information about the data capture. These data sources are accessed via hyperlinking in the GIS programs.
- **Metadata** - Digital photographs and field notes are provided that help explain the

data.

These types of data have been analyzed by NRL to develop innovative new products such as very shallow water bathymetric retrievals and trafficability maps. Operators without ArcGIS (or the Topographic Production Capability for U.S. Marines) will be able to view geospatial information with ArcGIS Explorer. Additional products derived by the HSI exploitation cell to support TS'09 can be added to the geodatabase.

3.3 Digital Data Files

Geodatabase files described in this report are from the TS'09 remote sensing campaign. Example files from the geodatabase are included as tables, appendices, and figures for this data report. Most of the map data and their metadata files, and a number of ArcGIS Explorer and ArcGIS projects are also included. Most of the data table files are tab-delimited text files, usable in spreadsheet and database software. The imagery and map data are in several formats for use in digital mapping software. Table 5 is a listing of primary paper maps and charts used during TS'09.

Table 5. Maps and charts of the study area.

Title/Series	Scale	Sheet/Edition	Date
Shoalwater Bay/Special	1:100 000	AUSSPEC0155/7-DTA	2000
Shoalwater Bay/Special	1:50 000	AUSSPE0349/1-DIGO	2008
Plans in Shoalwater Bay	1:25 000	Aus 261	2005
Port Clinton/1501(Air)	1:250 000	SF 56-9/3	1996
Port Clinton	1:25 000	Aus 248	3 Sept 2004
Mount Flinders/R733	1:50 000	9052 1/4-AAS	1996
Mount Flinders/Special	1:50 000	AUSPEC0345/1-DIGO	2008
Several of the nautical charts depict unsurveyed areas close to the shore within the approach to concave landing areas, i.e., pocket beaches.			

The types of data present in the TS'09 campaign can be broken down into data archived in geographical form (which are presented through ArcGIS Explorer or ArcGIS) and data that are not archived in geographical form. Appendix D describes access of attribute data within both geographic viewers. Attribute data can be accessed via either GIS program by linking to the "TS09_ALL_DATA.xlsx" spreadsheet. Types of data available on the geodatabase drive but not accessed through ArcGIS Explorer or ArcGIS are listed in Table 6.

Table 6. TS'09 data files. There are numerous TS'09 data types, including data tables, GIS files, spectra, and plot files. This table summarizes data that is not rendered through ArcGIS or ArcGIS explorer, but does appear on the geodatabase disk. These data are rendered through alternative means such as the operating system browser tools or packages such as ITT's ENVI**.**

Path	Folder	File Types/Notes
\TS09_GD\Attribute_Data\Multimedia	Pictures\	Work site photos. Photos of flora for ASD control. Soil experiment photos. Miscellaneous survey photos.
\TS09_GD\Attribute_Data\	ASD\	ASD_SUMMARY spreadsheet. Contains all site spectra, graphs, and comments about spectra.
\TS09_GD\Attribute_Data\	Backup\	Backup data. Raw data, intermediary files, .rfl files.
\TS09_GD\Attribute_Data\	RAW_ASD_DATA\	Raw rad files.
\TS09_GD\Attribute_Data\	Reflectance_files\	.rfl files containing average reflectance spectra for each site.
\TS09_GD\Attribute_Data\	Scripts\	Numerous IDL scripts for use in processing spectra.
\TS09_GD\Attribute_Data\	SpectralLibraries\	Spectral library files in spreadsheet and .sli (opens in ENVI) format
\TS09_GD\Attribute_Data\	HyMap…\	Folders contain headers, geocorrection files, georeferenced images, and quicklooks. Intermediary files are broken down by date and azimuth.

4. Visualization/Analysis

Trafficability is the ability of the terrain to support the movement of vehicles and people. Some of the important factors are vegetation density, bearing capacity, and shear strength of the soil. Analysis was conducted to classify HSI of SWBTA's littoral penetration area's trafficability as excellent, good, fair, poor, or bad.

4.1 Spectra Collection

Figure 5. FieldSpec ® 3 Spectroradiometer. Portable spectrometers are used to collect spectra (see ASD INC., Available online. URL: http://www.asdi.com/products-fs3.asp).

Researchers collected reflectance data from field spectrometers and from airborne spectrometers in order to study specific beaches. The ASD, Inc. FieldSpec®3 Spectroradiometer that is depicted in Figure 5 was one of four instruments of this or similar type used during TS'09. Vegetation density, grain sizes, beach composition, and soil moisture may be derived from the spectra, and from these, trafficability parameters can be estimated. Spectra collected during HI-TS'09 are provided in Appendix E.

4.2 Light Weight Deflectometer

Dynamic deflection modulus, measured in MN/m^2 (units are a measure of pressure), was determined by using a lightweight deflectometer (LWD). The Zorn ZFG 2000 LWD is depicted in Figure 6. Some of the factors upon which soil modulus depends, and which are pertinent for TS'09 are soil composition, soil moisture content, soil stress level, stress history, and age of the soil. Records of dynamic deflection modulus are provided in Appendix F.

Figure 6. Lightweight deflectometer being used to determine dynamic deflection modulus. It is a non-destructive test device most often used in civil engineering to measure pavement deflections by applying a dynamic load to the pavement surface.

4.3 Dynamic Cone Penetrometer

A Kessler Dynamic Cone Penetrometer (DCP) was used in accordance with ASTM D 6951-03 in order to measure soil shear strength. It functions by striking a cone tipped rod with a freefalling weight, thereby driving the cone into the soil. The distance the cone penetrates is measured and the process is repeated until the desired depth is achieved. The recorded data is most commonly plotted as the number of blows divided by the penetration of the cone. For TS'09 the CBR was determined using the Kessler DCP that is illustrated in Figure 7. Appendix G summarizes DCP testing done during TS'09.

Figure 7. Dynamic Cone Penetrometers being used to determine material shear strength. The left panel depicts the DCP and magnetic ruler. The right panel illustrates the typical use of the DCP. The number of blows and depth of penetration are used to compute CBR.

4.4 Soil Property Determination

Some of the oldest rocks and sediments in the region have come from offshore volcanic island chains such as the *Calliope Island Arc*, which extends along the east coast from central Queensland to the border of New South Wales. Others are believed to have come from deep-sea sediments that were smeared up onto the shelf by plate tectonics. Soil samples were collected with a corer. Soil moisture was determined by weighing a portion of the soil sample while wet and again after drying using a microwave oven. After sieving, the samples were described based on particle size (see Figures 8, 9, and 10). This allowed determination of the proportions of coarse, medium and fine sands, silt, and clay in a soil sample. A picture of a stack of sieves sitting in one of the shakers used to sort grain sizes is provided in Figure 11. Appendix H summarizes soil analysis testing done during TS'09.

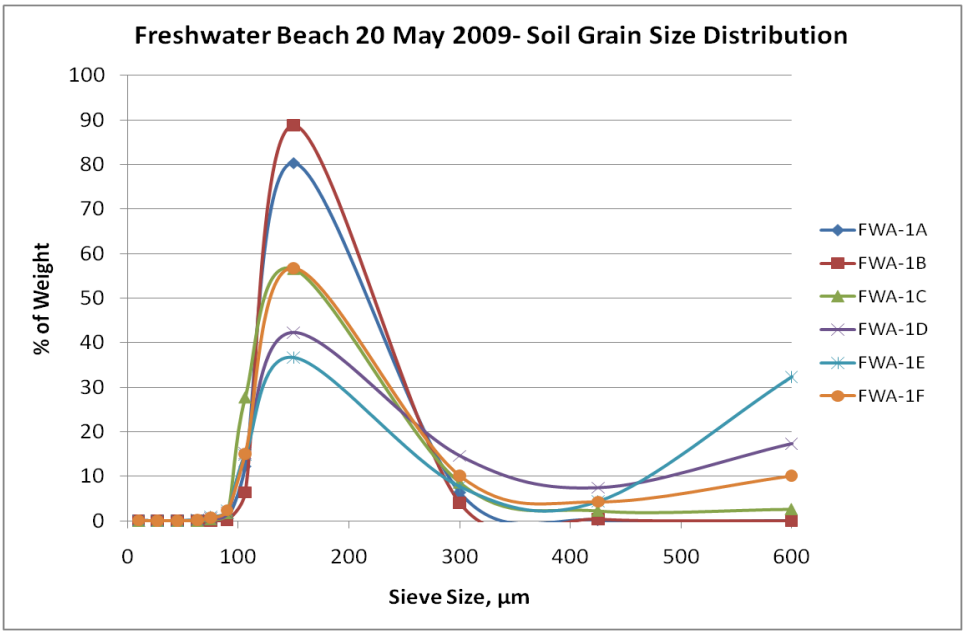


Figure 8. Grain size distribution along Freshwater Beach transect.

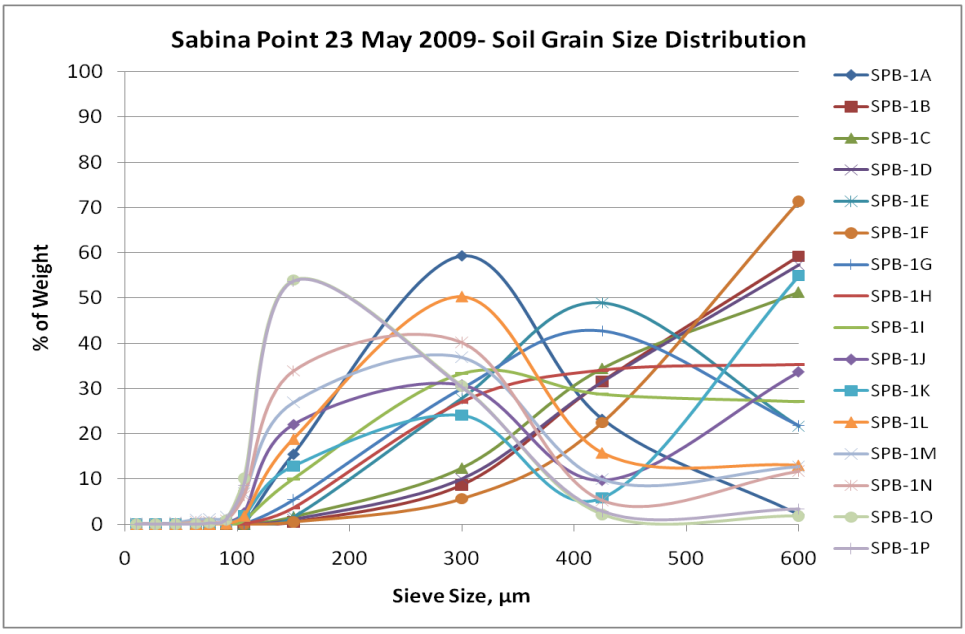


Figure 9.Grain size distribution along Sabina Point transect.

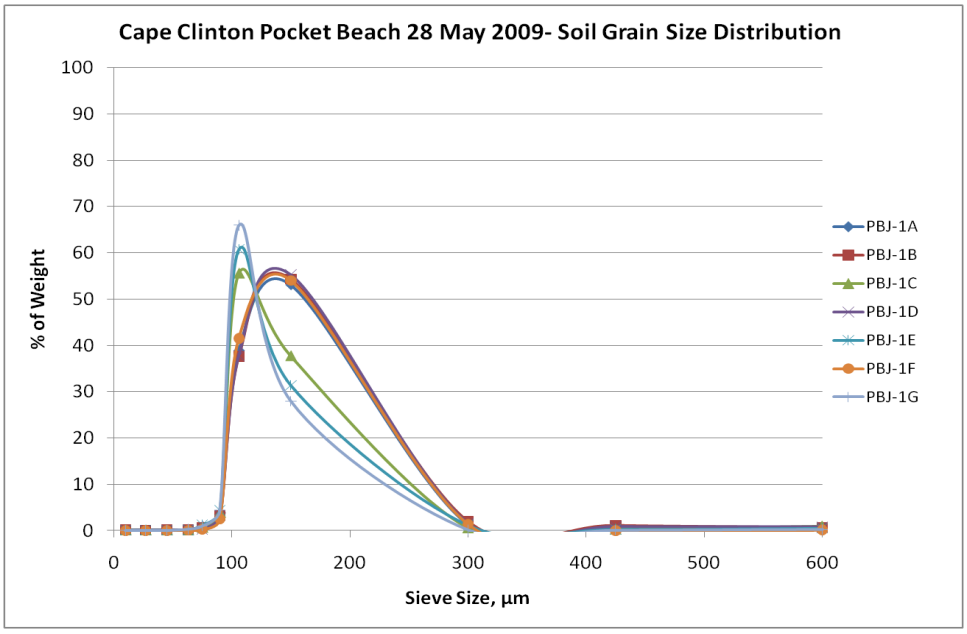


Figure 10. Grain size distribution along Cape Clinton pocket beach transect.

Figure 11. Sieves and shaker used to determine grain size distributions. .Two Humboldt H4325 sieve shakers were used to determine grain size distributions (see LABEQUIP LTD. Available online. URL: www.labequip.com).

4.5 Geotagged Photographs

A camera with a GPS component was used to take pictures of Freshwater Beach and Sabina Point. These photographs were taken from a vehicle at Freshwater beach on 19 May 2009 and 29 May 2009 and from a boat at Sabina Point on 23 May 2009. Views of the landing area at Freshwater Beach and Sabina Point are provided in each photograph. The photographs also provide information on submerged features, especially at Sabina Point. Display of these images can be done via both versions of the geodatabase. In both versions of the geodatabase, a point shapefile presents the point at which the photograph was captured. By clicking on the point, a pop-up screen displays the photograph. A map of photograph locations and spreadsheet of photograph information appears in Appendix I.

4.6 Water Level Data

A buoy constructed by participating NOAA team members was used to measure water levels at various sites within the study area during the cal/val effort. The buoy, as shown in Figure 12, utilized an Ashtech® Z-Xtreme™ dual-frequency GPS receiver to measure water level fluctuations with centimeter scale accuracies. It was constructed with a frame of PVC piping filled with floatation material and a wooden base for positioning of the kinematic GPS unit. The GPS computer unit was located inside a watertight plastic container while the receiver was positioned on top of a wooden base above the container. Figure 13 highlights locations where the water level buoy was deployed in order to record water level height. The buoy was deployed from 20 to 22 May 2009 and on 27 May 2009 at Freshwater Beach, at Sabina Point on 23 May 2009, in South Arm estuary near Seahound boat ramp on 25 May 2009, and at the pocket beach study at the northern point of Cape Clinton on 28 May 2009. Buoy water level time series are provided in Appendix J.

Figure 12. NOAA water level buoy shown with Danforth anchor and rope. This water level buoy, containing a kinematic GPS, was manually deployed from a boat during the cal/val campaign and was used to accurately determine water levels at the time of HyMap imagery acquisition.

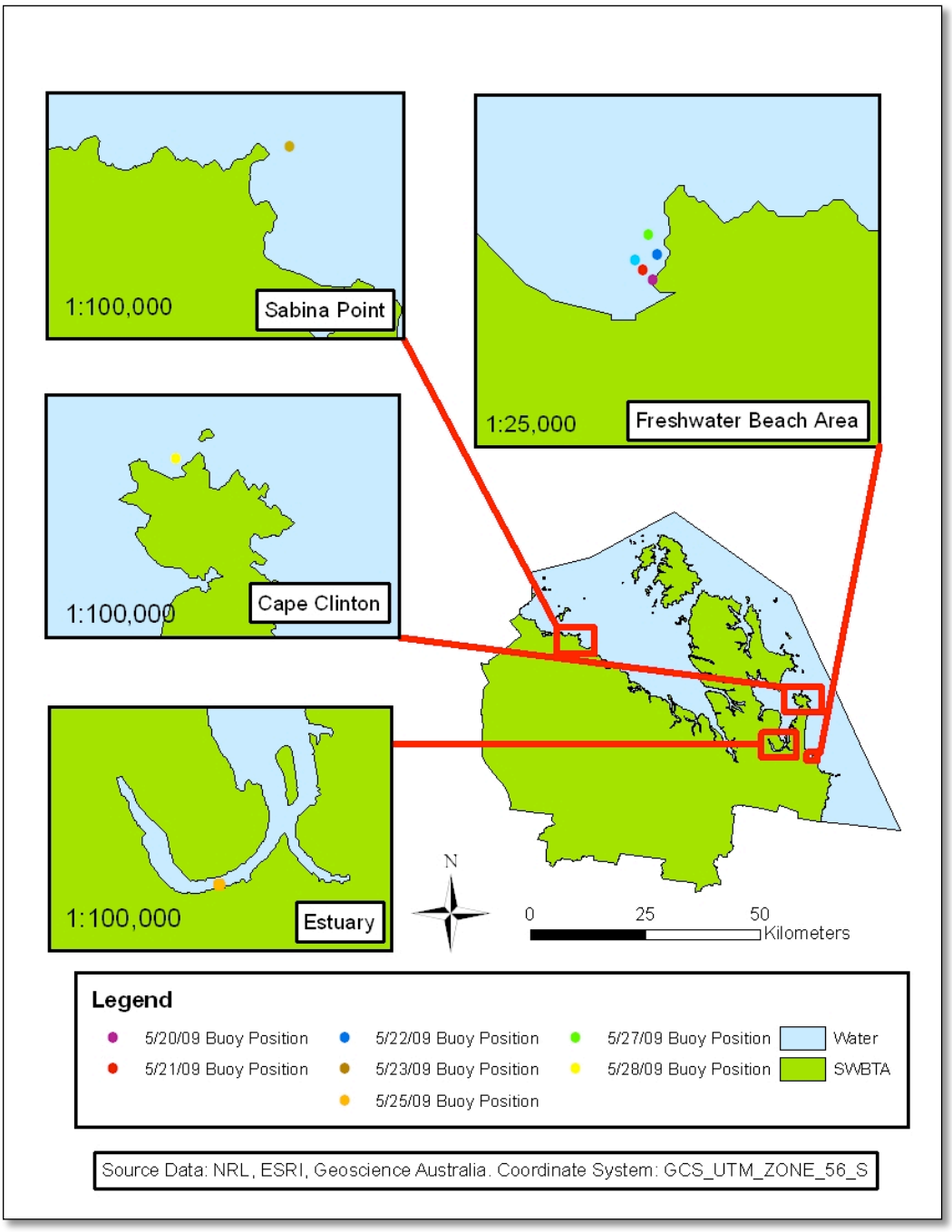


Figure 13. NOAA water level buoy positions during TS'09. Areas located on the map indicate where the buoy was collecting water level height data.

4.7 Kinematic GPS Data

Survey data collected by team members from NOAA were of sufficient resolution to help calibrate and evaluate the accuracy of the HyMap airborne imagery. The GPS data was also instrumental in bringing topographic data, such as beach profiles measured with a kinematic GPS, into a common reference frame. Figure 14 highlights the distribution of elevation measurements along Freshwater Beach and Sabina Point at SWBTA from the kinematic GPS. A picture of the fixed base station is provided in Figure 15. The base allows differential corrections to be made with the "kinematic" or mobile GPS receiver.

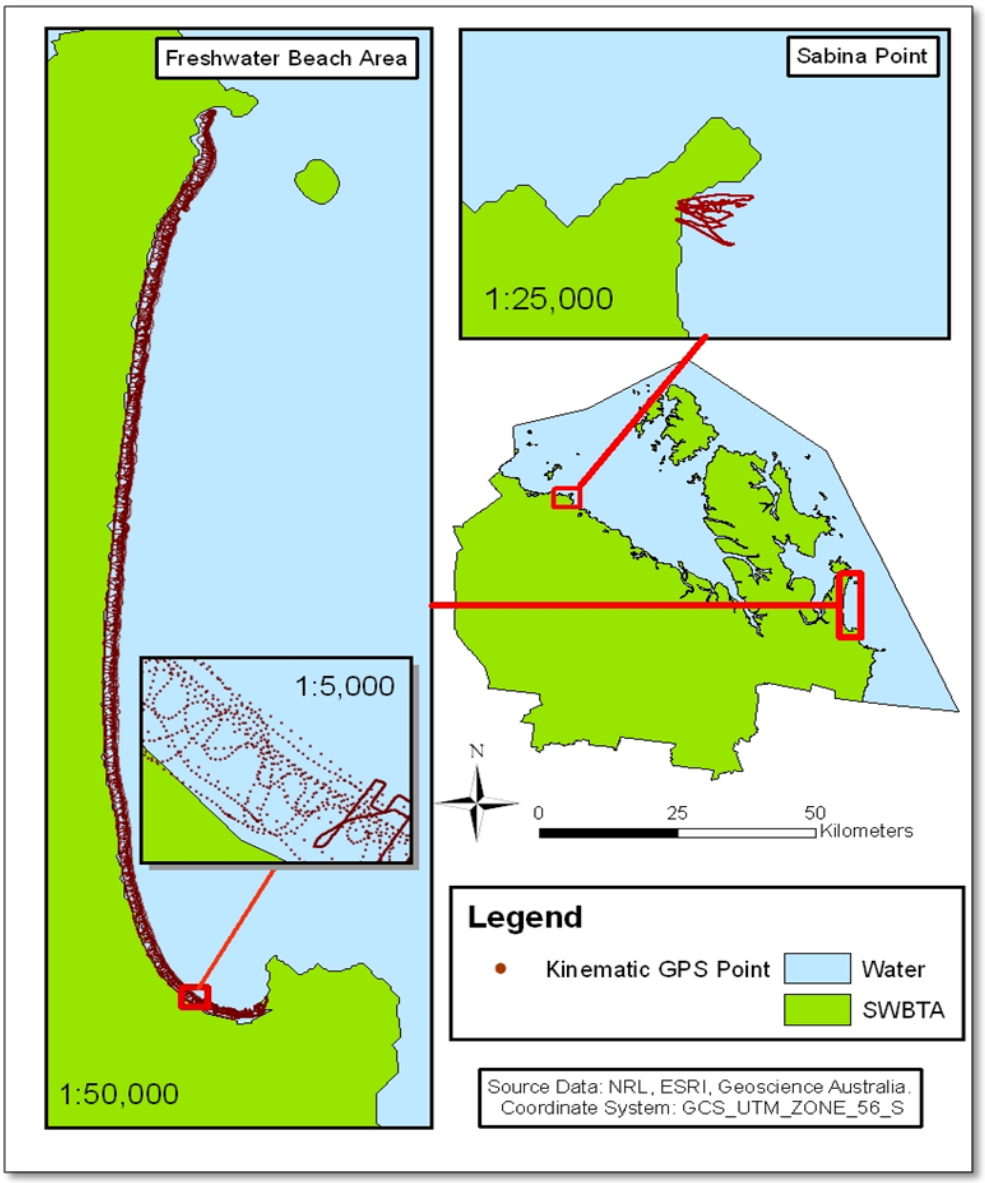


Figure 14. Kinematic GPS positions during TS'09.

Figure 15. NOAA GPS base station at Freshwater Beach. This base station was used to finely tune the positioning of rover units used to record beach profiles in the intertidal zone**.**

4.8 Ground Control Points

The utility of using hyperspectral data from HyMap or ARTEMIS lies in the ability to detect and identify scene materials based on their spectral signature characteristics. For this reason, calibration panels were deployed near Freshwater Beach. They were used to produce calibration data suitable for converting radiance data from hyperspectral sensors to units of apparent reflectance. In addition, blue tarps were surveyed in and are helpful in determining edge response, imagery resolution, and geo-referencing. These ground control points are shown in Figure 16. These survey data are provided in Appendix J.

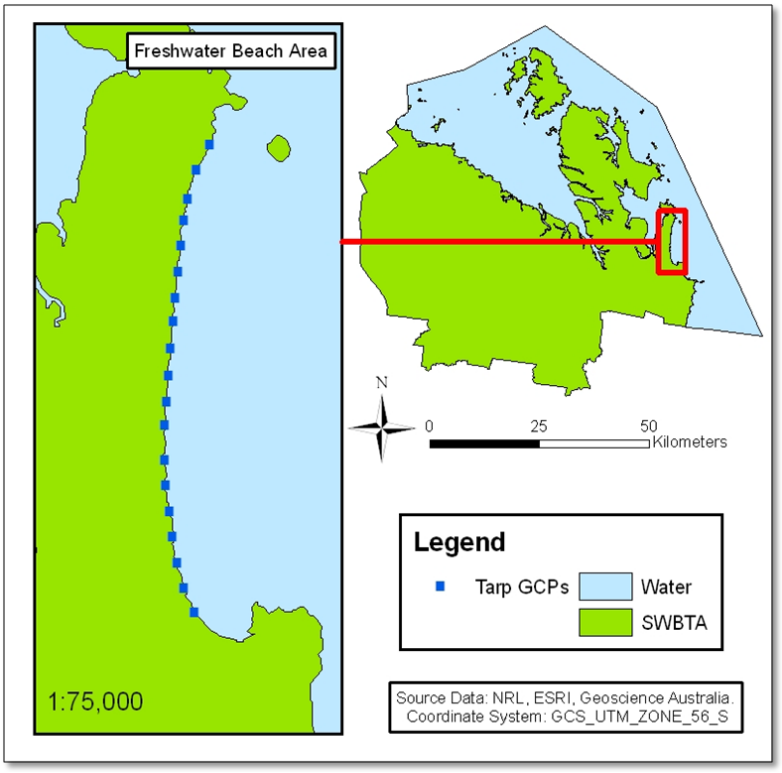


Figure 16. Blue tarp GCPs (ground control points).

5 Acknowledgments

This fieldwork was a collective effort that involved a wide network of individuals and institutions beyond those that actually collected data, provided analyses, and wrote reports. Dr. Charles Bachmann was the principal investigator and was greatly aided by the efforts and insights of Mr. Gordon Mattis, the Science Advisor at Marine Corps Forces Pacific. This compilation of data represents the work of many individuals throughout the Naval Research Laboratory, Naval Postgraduate School, National Oceanic and Atmospheric Administration, and Australian Defence Force. We are specifically grateful to the support and assistance from Warrant Officer Class 2 David Renton, our coxswain, Majors Bill Wattam and Bob Kebby, our LNOs, and LtCOL Greg Thompson, the lead planner for TS'09 experiments.

The TS'09 remote sensing campaign was funded by the Office of Naval Research. Of particular importance was support from Dr. Larry Schuette and Mr. Jim Blessé from SwampWorks who were particularly interested in exploring how airborne hyperspectral imagery and ARTEMIS might advance the capabilities of Navy and Marine Corps war fighters. Additional funding was provided by Dr. Chung Hye Read of NGA Innovision at the conclusion of the exercise to support analysis and reporting related to the data collected and processed during TS'09.

6. References

ASTM Standard E 2583 – 07, "Standard Test Method for Measuring Deflections with a Light Weight Deflectometer (LWD)," ASTM International, West Conshohocken, PA, www.astm.org.

Bachmann, C. M., C. R. Nichols, M. J. Montes, RR. Li, P. Woodward, R. A. Fusina, W. Chen, M. Crawford, W. Kim, V. Mishra, J. Monty, K. McIlhany, D. Korwan, D. Miller, E. Bennert, G. Smith, D. Gillis, G. Marmorino, J. Sellars, C. Parrish, A. Schwarzschild, B. Truitt, 2008a. "Remote Sensing Retrieval of Substrate Bearing Strength from Hyperspectral Imagery at the Virginia Coast Reserve (VCR'07) Multi-Sensor Campaign," Proc. IGARSS'08.

Bachmann, C. M., M. J. Montes, R. A. Fusina, C. Parrish, J. Sellars, A. Weidemann, W. Goode, V. Hill, R. Zimmerman, C. R. Nichols, P. Woodward, K. McIlhany, D. Korwan, M. Crawford, J. Monty, B. Truitt, A. Schwarzschild, 2008b. "Very Shallow Water Bathymetry Retrieval from Hyperspectral Imagery at the Virginia Coast Reserve (VCR'07) Multi-Sensor Campaign," Proc. IGARSS'08.

Bachmann, C. M., C. R. Nichols, M. Montes, R. Li, P. Woodward, R. A. Fusina, W. Chen, V. Mishra, W. Kim, J. Monty, K. McIlhany, K. Kessler, D. Korwan, D. Miller, E. Bennert, G. Smith, D. Gillis, J. Sellers, C. Parrish, A. Schwarzschild, B. Truitt, 2010. "Retrieval of Substrate Bearing Strength from Hyperspectral Imagery During the Virginia Coast Reserve (VCR '07) Multi-Sensor Campaign," *Marine Geodesy, 33:53-75*.

Bachmann, C. M., M. J. Montes, R. A. Fusina, C. Parrish, J. Sellars, A. Weidemann, W. Goode, V. Hill, R. Zimmerman, C. R. Nichols, P. Woodward, K. McIlhany, D. Korwan, M. Crawford, J. Monty, B. Truitt, A. Schwarzschild, in press. Bathymetry Retrieval from Hyperspectral Imagery in the Very Shallow Water Limit: A Case Study from the 2007 Virginia Coast Reserve (VCR'07) Multi-Sensor Campaign, Marine Geodesy, in press.

Bureau of Meteorology, Australian Government. Available online. URL: http://www.bom.gov.au/. Accessed on April 6, 2009.

Curcio, J.A., C. C. Petty, 1951. "The Near Infrared Absorption Spectrum of Liquid Water," J. Optical Soc. Amer., Vol. 41, No. 5, pp. 302-304.

Enivornmental Systems Research Institute (ESRI). ArcGIS Explorer 900. Available Online. URL: http://www.esri.com/software/arcgis/explorer/index.html. Accessed on October 21, 2009.

FAO-UNESCO. 1974. *FAO-UNESCO Soil map of the world 1:5,000,000*. Paris: UNESCO.

Hallenborg and Nichols, TACSAT-3/ARTEMIS Joint Military Utility Assessment: Department of the Navy Hyperspectral Technology Demonstration in Talisman Saber 09, Space and Naval Warfare (SPAWAR) Systems Center – Pacific, San Diego, CA, September, 2009.

ISRIC (International Soil Reference and Information Center). Soil and terrain database (SOTER). Wageningen, Netherlands: ISRIC. Available online. URL: http://www.isric.org/isric/webdocs/Docs/soterfolder001.pdf. Accessed on January 7, 2008.

Jones, C. Littoral Trafficability Prediction by Hyperspectral Imagers, Master's Thesis, Naval Postgraduate School, Monterey, California, 25 September 2009.

Mobley, C.D., *Light and Water: Radiative Transfer in Natural Waters*, San Diego, CA: Academic Press, 1994.

Mobley, C. D and L. K. Sundman, 2000. Hydrolight 4.1 Technical Documentation. Seattle: Sequoia Scientific, Inc.

Mobley, C.D., W. P. Bissett, J. H. Bowles, C. O. Davis, T. V. Downes, A. Gleason, D. D. R. Kohler, R. A. Leathers, E. M. Lochard, M. J. Montes, R. P. Reid, L. K. Sundman, 2005. "Interpretation of hyperspectral remote-sensing imagery via spectrum matching and look-up tables, Applied Optics," 44(17): 3576-3592.

Montes, M. J., B.-C. Gao, C. O. Davis, 2004. ``NRL Atmospheric Correction Algorithms for Oceans: Tafkaa User's Guide," Naval Research Laboratory Memorandum Report 7230--04-8760, March 2004.

Nichols, C. Reid and Robert G. Williams, *Encyclopedia of Marine Science*. New York: Facts On File, 2008.

Zorn Company, Operating Manual: Light Drop-Weight Tester ZFG 2000 (Light Weight Deflectometer, Portable Falling Weight Deflectometer) for the dynamic plate loading test, corresponding to the German "Technical Specification for Soil and Rock in Road Construction," TP BF – StB Teil B 8.3. Stendal, Germany, 1992 – 2005.

APPENDIX A

Web Resources

Introduction

There is considerable information relevant to TS09 and the exploitation of hyperspectral imagery stored on the World Wide Web. Therefore, the following list of Uniform Resource Locators (URLs) is provided since they complement this data report.

Aerosol Optical Depth, Earth Observatory, NASA, Available online. URL: http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MODAL2_M_AER_OD#, Accessed on June 24, 2009.

Global scale maps show average monthly aerosol amounts around the world based on observations from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite. Satellite measurements of aerosols, called *aerosol optical thickness,* are based on the fact that the particles change the way the atmosphere reflects and absorbs visible and infrared light. An optical thickness of less than 0.1 (palest yellow) indicates a crystal clear sky with maximum visibility, whereas a value of 1 (reddish brown) indicates very hazy conditions.

Asia-Pacific Area Network (APAN). Available online. URL: http://www1.apan-info.net/ts. Accessed on September 17, 2008.

APAN is a web portal offering information resources on exercises such as TALISMAN SABER and a collaborative planning environment. APAN tools include Training Objective Matrix (TOW), Joint Training Information Management System (JTIMS), Joint Master Scenario Events List (JMSEL), Enterprise Platform for Information Collaboration (EPIC), and a Lessons Learned Tool. APAN is hosted by the Commander, U.S. Pacific Command, Camp Smith, Hawaii.

Australian Quarantine and Inspection Service. Available online. URL: http://www.daffa.gov.au/aqis/avm/military/talisman-saber-2009. Accessed on November 17, 2008.

The Australian Quarantine and Inspection Service (AQIS) which is part of the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) provides inspections for all equipment coming into Australia for TS09. An advance party from the Naval Research Laboratory traveled to Brisbane, Australia to ensure all equipment was ready for AQIS from 7-13 May 2009. Once inspected by AQIS, equipment was then shipped to Shoalwater Bay Training Area (SWBTA) near Byfield, Australia. At the Australian Defence Force facility in Rockhampton, Australia, all rental vehicles were cleaned and inspected prior to being operated in the SWBTA.

Bureau of Meteorology, Australian Government. Available online. URL: http://www.bom.gov.au/. Accessed on May 1, 2009.

An official site to access weather forecasts and tide predictions. Weather observations were made at Samuel Hill, Station Number 033308, at the SWBTA. A reference station is located at Gladstone and the closest secondary station is Port Clinton. Tide predictions at Port Clinton are 34 minutes after Gladstone. These secondary station predictions are calculated by

applying an adjustment to the time and height of tide for the reference station.

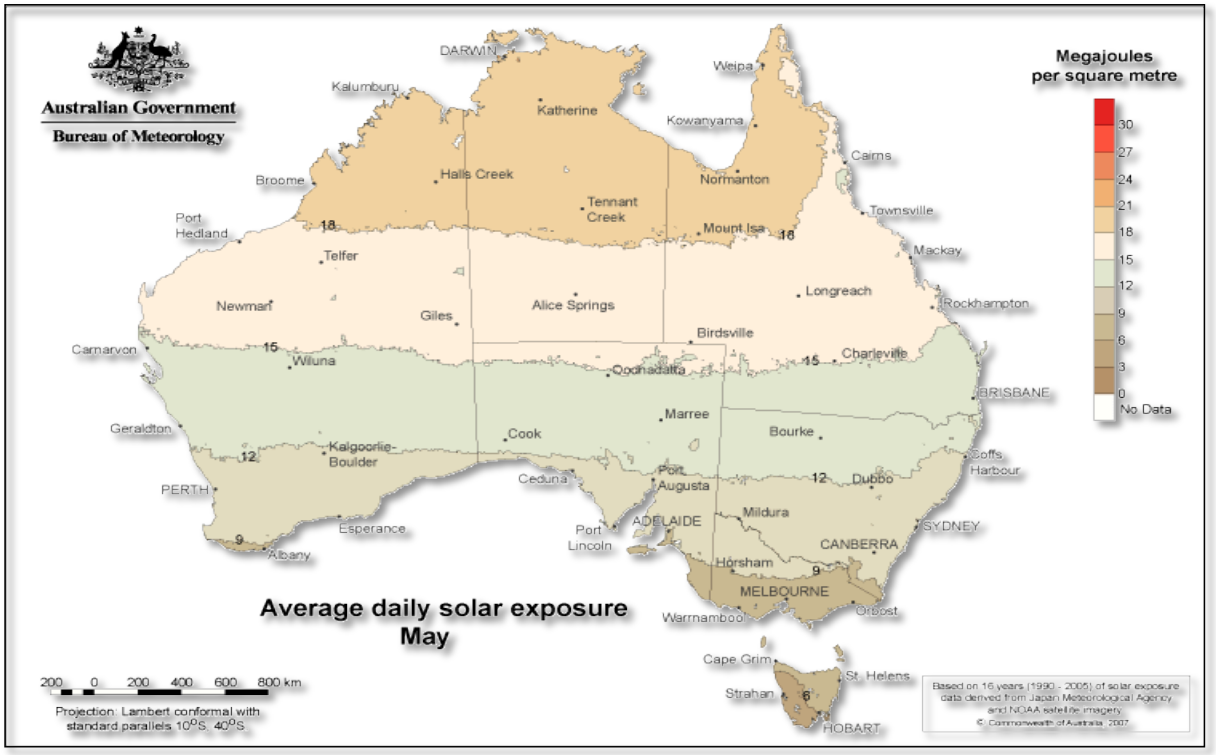


Figure 1.Average daily solar exposure for May. Typical values for daily global solar exposure range from 1 to 35 MJ/m^2 (megajoules per square metre). For mid-latitudes, the values are usually highest in clear sun conditions during the summer, and lowest during winter or very cloudy days.

Honolulu Botanical Gardens. Available online. URL: http://www.co.honolulu.hi.us/parks/hbg/index1.htm. Accessed on January 7, 2008.

During the Mid Planning Conference for Talisman Saber'09 and during HI-HARES'09, research scientists visited the approximately 0.1 km^2 Foster Botanical Garden to obtain spectra of vegetation indigenous to Oahu and from several specialty gardens, spectra of plants common to Australia. On November 19, 2008, Dr. Charles Bachmann, Mr. Gordon Mattis and Mr. Reid Nichols, and USMC Capt Chris Jones were aided by Ms. Naomi Hoffman, a botanist, in the collection of data on species listed in Table 1. Field spectra were collected from selected leaf samples.

Table 1. Plant species studied at Foster Botanical Garden on November 19, 2008.

Scientific Name	Common Name	Remarks
Acacia koa	Koa	Endemic to Hawaiia.
Aleurites moluccana	Kukui	Distributed throughout tropical regions.
Chamaesyce degeneri	Akoko	Endemic to Hawaiia.
Coix lacryma-jobi	Job's tear	Common along streams and ditches in Hawaii.
Colocasia esculenta	taro	Native to tropical Polynesia and southeastern Asia.
Cordia sebestena	Kou haole	Found worldwide, mostly in warmer regions.
Cordyline fruticosa	Ti plant	It is native to tropical Asia, Australia, the Indian Ocean, and parts of Polynesia.
Curculigo capitalata	palm grass	Arching palm-like leaves, evergreen in protected areas, small yellow flowers in summer
Gossypium tomeutosum	Ma'o	A shrub found in Hawaii that grows in dry, rocky, or clay coastal plains.
Hibiscus brackenridgei	Ma'o Hau Hele	Found in dry forests and Hawaiian tropical low shrublands.
Hyophorbe verschaffeltii	spindle palm	Found in tropical coastal savannas and hilly forests worldwide due to cultivation.
Macrozamia miquelii	Zamia bush	Found in Queensland Australia.
Myoporum sandwicense	Naio	Endemic to Hawaii.
Ophiopogon japonicus	mondo grass	Ground cover found in temperate and tropical Asia.
Pandanus tectorius	Hala	Found on Pacific islands, in Micronesia, in Melanesia, and as far west as northern Australia.
Pittosporum undulatum	mock orange	Native to the coastal belt and mountains of south-eastern Australia.
Pritchardia remota[1]	Loulu	Palm tree found in Hawaii and being cultivated in botanical gardens.
Terminalia catappa	tropical almond	Widespread in subtropical and tropical zones of Indian and Pacific Oceans; planted extensively throughout the tropics.
Thespesia populnea	Milo	Tropical and subtropical distribution.
Veitchia montgomeryana	Montgomery palm	Native to Vanuatu.
For specifics on Hawaiian plants see Eileen Herring, Thesis Project: Hawaiian Native Plant Propagation Database, Available online. URL: http://pdcs.ctahr.hawaii.edu:591/hawnprop/default.htm, Accessed November 17, 2008.		

***Supplementary Environmental Report Talisman Saber 05*, Australian Defence Force, EPBC Act Referral. Available online. URL: http://www.maunsell.com/media/4418.pdf. Accessed on June 24, 2009.**

A summary report prepared by Maunsell Australia Pty Ltd describing the environment and Australian Defence Force activities taking place at the Shoalwater Bay Training Area. This report also explains safeguards which mitigate the impact of military activities on the

[1] Several *Pritchardia* species are listed as endangered under the US Endangered Species Act and are only found in cultivation in botanical gardens.

environment. Additionally, a detailed risk assessment planning process that is conducted by exercise planners is fully explained.

***SWBTA State of the Environment Report 2008*. Estate Policy and Environment Branch, Department of Defence, CANBERRA ACT 2600. Available online. URL: http://www.defence.gov.au/environment/swbta_report.htm. Accessed on June 24, 2009.**

A descriptive report which synthesizes information from many sources, both internal and external to the Australian Department of Defence. This report describes many of the environmental factors which impact military operations. In reporting the environmental attributes of SWBTA and their condition, this report seeks to compare environmental performance of the Area with adjacent landscapes and protected areas.

***Shoalwater Bay Seagrasses*, Great Barrier Reef Marine Park Authority, Australian Government. Available online. URL: http://www.gbrmpa.gov.au/__data/assets/pdf_file/0013/2722/rp44_intro_methods_analy.pdf. Accessed on June 24, 2009.**

A descriptive report which highlights the distribution and abundance of submerged aquatic vegetation (SAV) by seasons. Bottom types are described and maps are provided to locate SAV beds.

Tunstall, B., Marks, A., Reece, P., 1998. Vegetation and Soil Mapping Shoalwater Bay Training Area, CSIRO Land and Water Technical Report 9/98, Available online. URL: http://www.clw.csiro.au/publications/technical98/tr9-98.pdf. Accessed on June 24, 2009.

A summary of vegetation and soil mapping at the SWBTA. New methods are described and GIS coverage maps are presented.

U.S. Geological Survey, Global Visualization Viewer. Available online. URL: http://glovis.usgs.gov/. Accessed on June 24, 2009.

The USGS Global Visualization Viewer or GloVis provides Landsat and EO-1 ALI and Hyperion datasets for download at no charge. The Earth Observing 1 (EO-1) satellite has three imaging sensors: the multispectral Advanced Land Imager (ALI), the hyperspectral Hyperion sensor, and the Atmospheric Corrector. Hyperion is a high-resolution hyperspectral imager capable of resolving 220 spectral bands (from 0.4 to 2.5 micron) with a 30 m resolution. The instrument images a 7.5 km by 100 km surface area. Prior to the launch of TACSAT-3/ARTEMIS, Hyperion was the only source of spaceborne hyperspectral imaging data.

U.S. Marine Corps Forces Pacific. Available online. URL: http://www.mfp.usmc.mil. Accessed on January 7, 2008.

A PME was conducted at MARFORPAC by NRL and AFRL scientists during January 2008 on hyperspectral Imagery and the TACSAT-3/ARTEMIS experiment. The Chief of Staff directed the Science Advisor to include ARTEMIS as an experiment during TS09. Primary sponsors for Talisman Saber were the Science Advisor, AC/S G-2, representatives from the

MARFORPAC Experimentation Center (MEC), and exercise planners from the PACOM J-8. Exercise proposals and presentations were delivered to the MEC and PACOM J-8. Data collected during HI-HARES was planned to be made available to various military planning personnel from 31st MEU, MARFORPAC, MCIA, and NAVOCEANO during the TS09 Staff Exercise.

Wetland Info, Department of Environment and Resource Management, Queensland Governement, Australia. Available online. URL: http://www.epa.qld.gov.au/wetlandinfo/site/index.html, Accessed on June 24, 2009.

A web site which characterizes a variety of wetlands that are found in Queensland. Information that is provided includes data on wetland soils, water quality, flora and fauna. In addition, Wetland Info provides maps and data that are used in management, planning, assessment, research and rehabilitation projects.

APPENDIX B

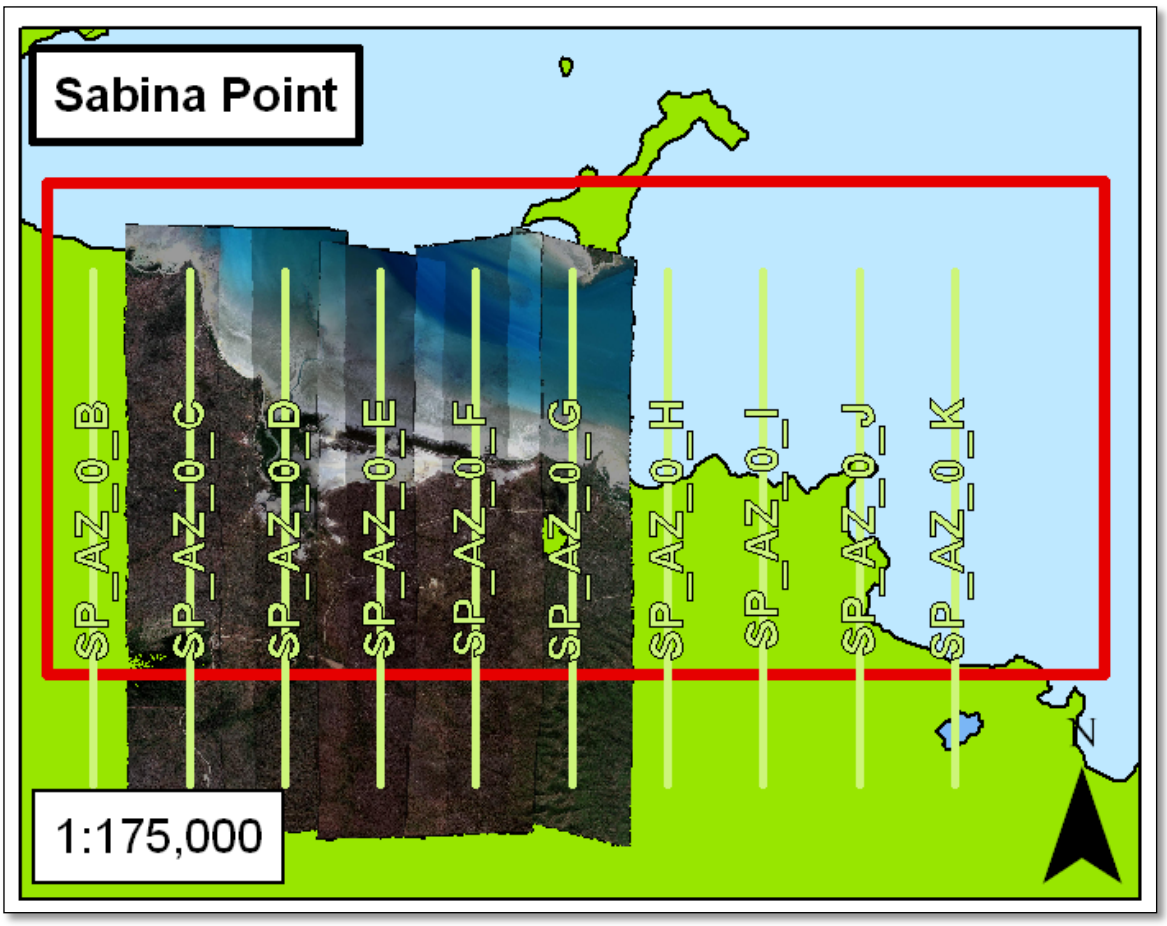
Flight Lines

1. Introduction

Talisman-Saber 2009 flight lines were planned to achieve a nominal ground sample distance (GSD) of about 3m with an approximate swath of about 1.8 km. An overlap of approximately 20% (which is about 300 m) between adjacent flight lines was achieved in order to prevent any data gaps from small variations in the planned flight-lines. To minimize glint from the water, flights were flown when solar zenith angles were between 30-60°. In addition, flights were flown into and out of the sun to further minimize glint as illustrated in the following solar azimuth heading figures. Section 2 displays the flight lines that were flown by the aircraft.

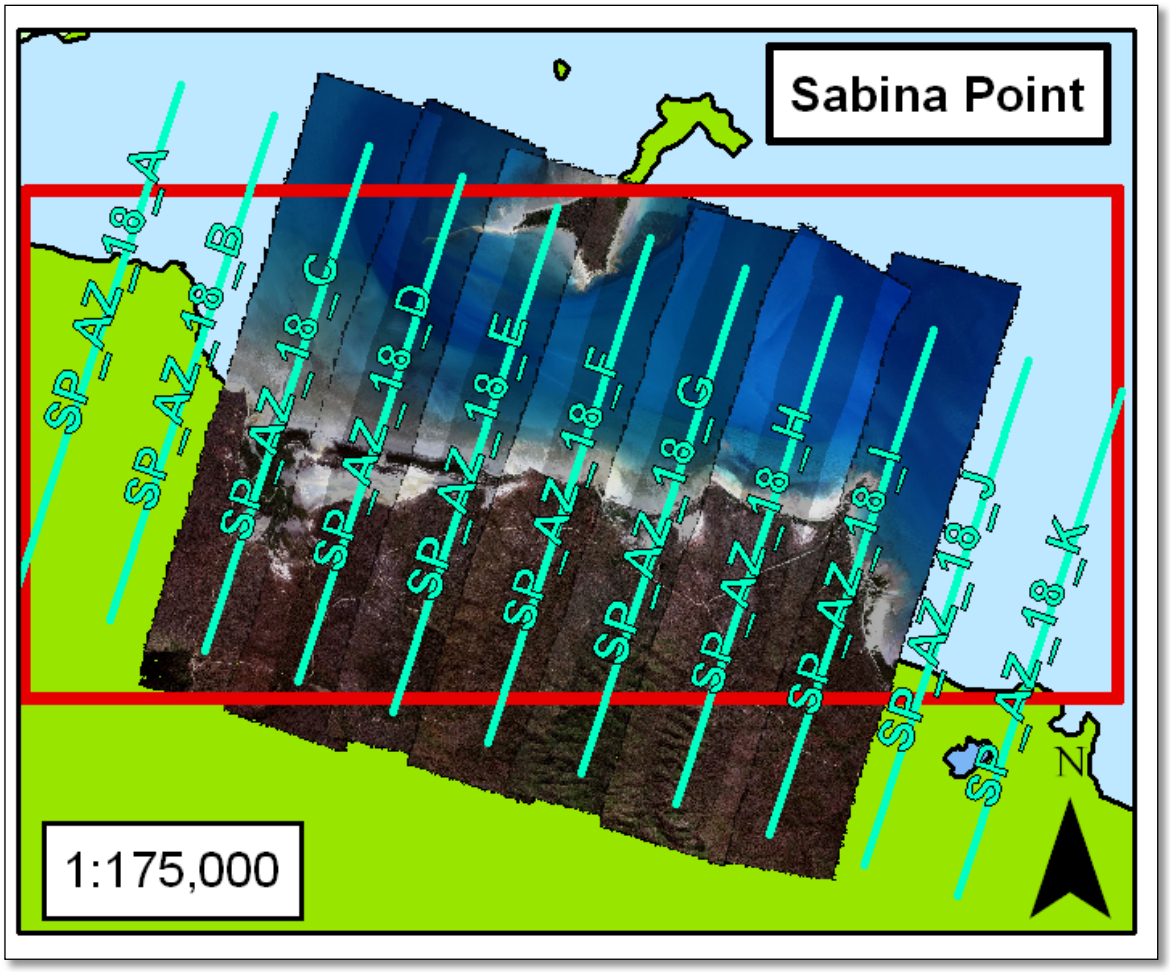
2. Flight Lines

2.1 Sabina Point- Azimuth 0 Flight Lines



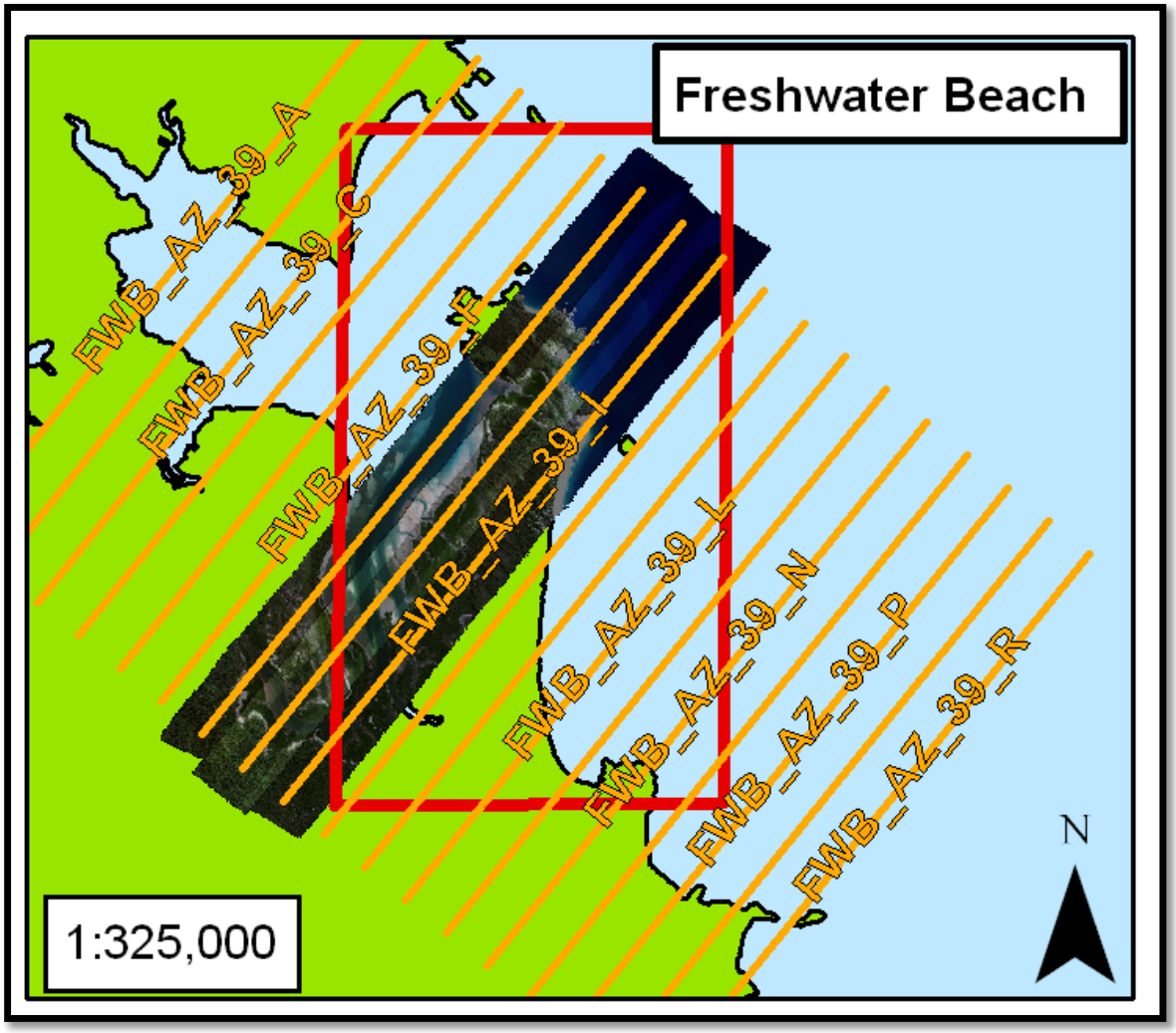
Flight-line boxes with heading along 0 degrees solar azimuth, allowing flights approximately into and out of the sun in order to minimize glint. The HyMap quicklooks can be seen below the name of the flight line. The line appears in the middle of each quicklook image. These flight lines were flown on May 21, 2009. Flight lines not associated with an image were not flown.

2.2. Sabina Point-Azimuth 18 Flight Lines



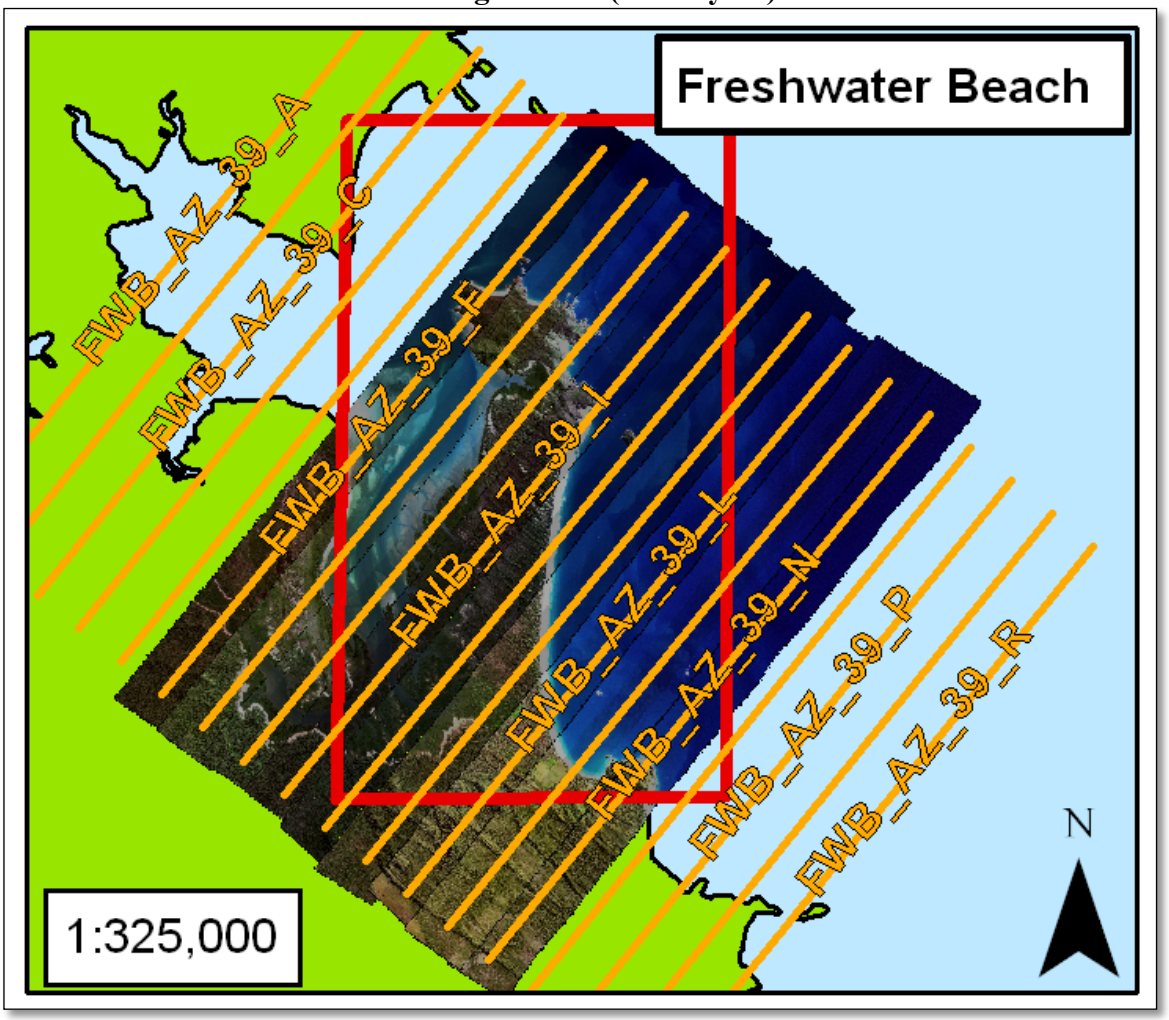
Flight-line boxes with heading along 18 degrees solar azimuth, allowing flights approximately into and out of the sun in order to minimize glint. The HyMap quicklooks can be seen below the name of the flight line. The line appears in the middle of each quicklook image. These flight lines were flown on May 21, 2009. Flight lines not associated with an image were not flown.

2.3 Freshwater Beach- Azimuth 39 Flight Lines (21-May-2009)



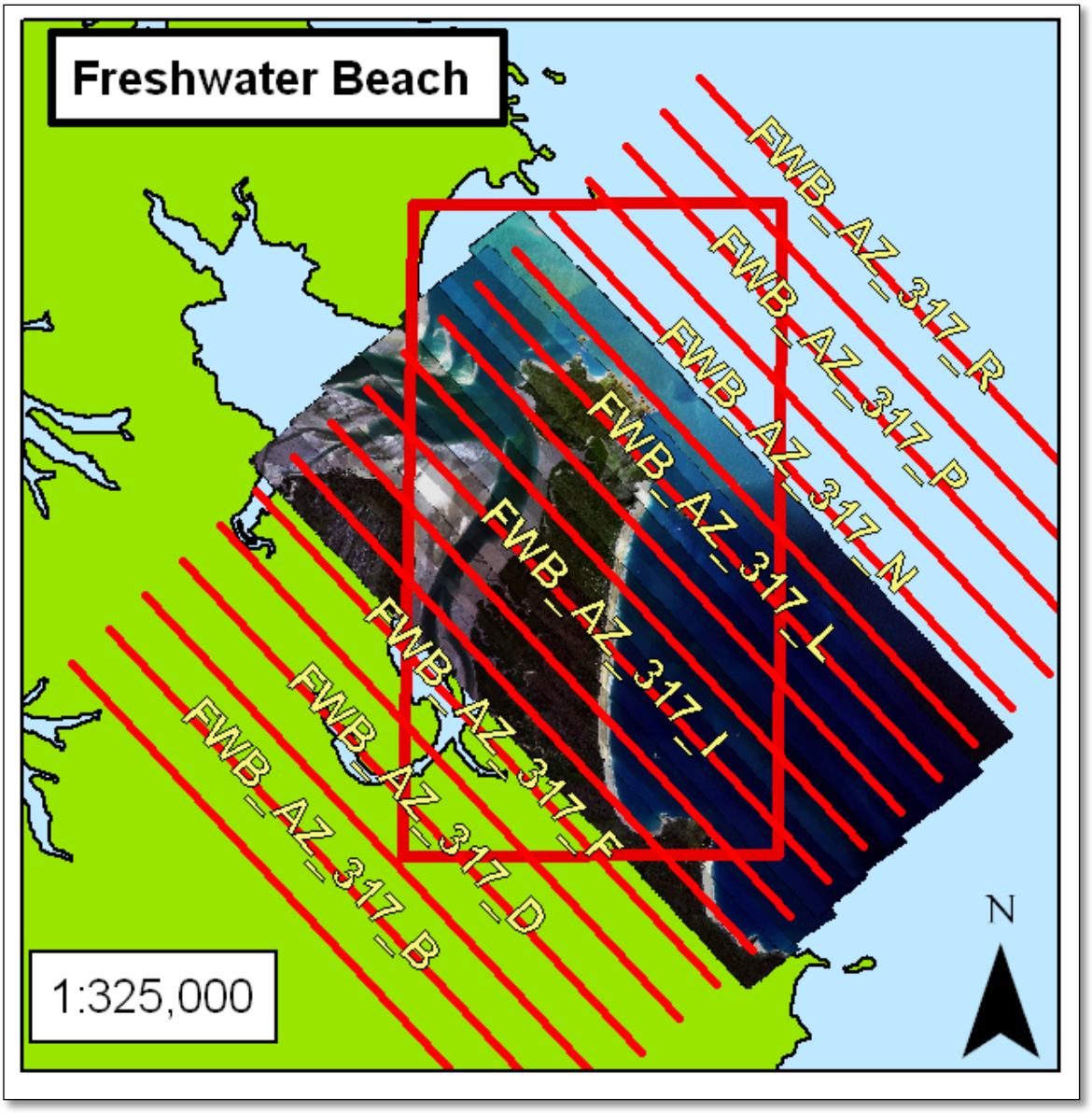
Flight-line boxes with heading along 39 degrees solar azimuth, allowing flights approximately into and out of the sun in order to minimize glint. The HyMap quicklooks can be seen below the name of the flight line. The line appears in the middle of each quicklook image. These flight lines were flown on May 21, 2009. Flight lines not associated with an image were not flown. Flight lines flown on this day include FWB_AZ_39_G, FWB_AZ_39_H, and FWB_AZ_39_I.

2.4 Freshwater Beach-Azimuth 39 Flight Lines (22-May-09)



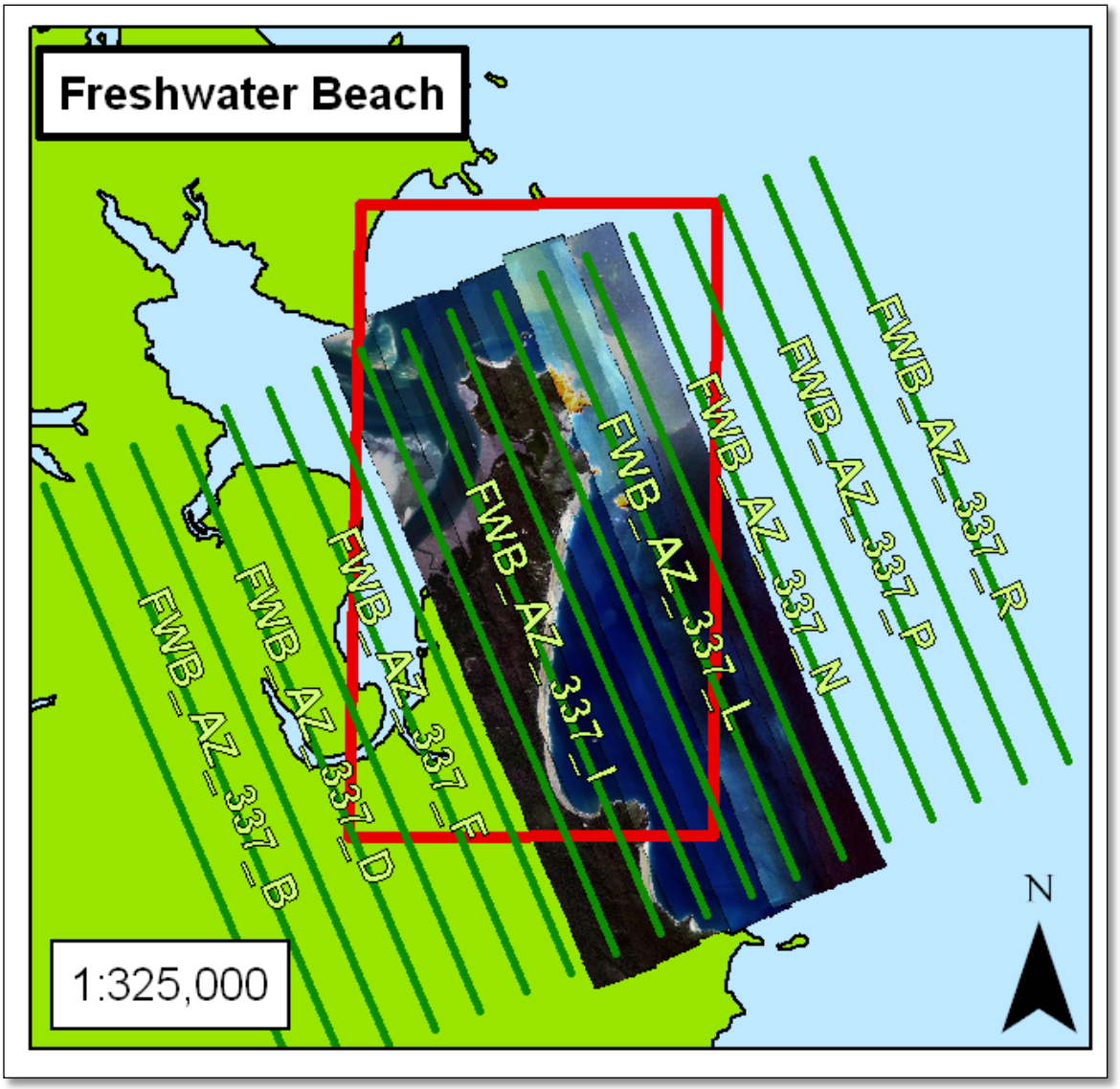
Flight-line boxes with heading along 39 degrees solar azimuth, allowing flights approximately into and out of the sun in order to minimize glint. The HyMap quicklooks can be seen below the name of the flight line. The line appears in the middle of each quicklook image. These flight lines were flown on May 22, 2009. Flight lines not associated with an image were not flown.

2.5 Freshwater Beach-Azimuth 317 Flight Lines



Flight-line boxes with heading along 317 degrees solar azimuth, allowing flights approximately into and out of the sun in order to minimize glint. The HyMap quicklooks can be seen below the name of the flight line. The line appears in the middle of each quicklook image. These flight lines were flown on May 23, 2009. Flight lines not associated with an image were not flown.

2.6. Freshwater Beach- Azimuth 337 Flight Lines



Flight-line boxes with heading along 337 degrees solar azimuth, allowing flights approximately into and out of the sun in order to minimize glint. The HyMap quicklooks can be seen below the name of the flight line. The line appears in the middle of each quicklook image. These flight lines were flown on May 23, 2009. Flight lines not associated with an image were not flown.

APPENDIX C

Imagery Quicklooks

1. Introduction

HyMAP imagery is found at the path \TS09_GD\Attribute_Data\HyMap… and is divided by folder into each data and azimuth. Imagery quicklooks are also found in folders at this path. The folder hierarchy is illustrated in Table 1.

Table 1. HyMAP Data Folder Hierarchy.

Filepath	Folder(s)	Contents/Folder Name
\TS09_GD\Attribute_Data\HyMap…	Shoalwater_20090521, Shoalwater_20090522, Shoalwater_20090523,	Each of the date folders contain folders of each of the individual flight lines flown at different azimuths, as well as the "geocorrection," "georeferenced," and "quicklooks" folders.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090521	FWB_AZ_39_G, FWB_AZ_39_H, FWB_AZ_39_I ,SP_AZ_0_C, SP_AZ_0_D, SP_AZ_0_E, SP_AZ_0_F, SP_AZ_0_G, SP_AZ_18_C, SP_AZ_18_D, SP_AZ_18_E, SP_AZ_18_F, SP_AZ_18_G, SP_AZ_18_H, SP_AZ_18_I.	Each of the flight line folders contains information on/about image products and related files; folder names are auxiliary, mask, radiance, and Tafkaa. "Tafkaa" contains a version of the data as reflectance, obtained by running NRL's TAFKAA atmospheric correction software
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090521	FWB_QuickLooks_20090521, SP_QuickLooks_20090521	Contains one JPEG image for each of the flight lines.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090521	Geocorrection	Contains data files with associated ENVI header files for each of the flight paths.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090521	Geoferenced	Contains atmospherically and georeferenced reflectance images of each flight path.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090522	FWB_AZ_39_F, FWB_AZ_39_G, FWB_AZ_39_H, FWB_AZ_39_I, FWB_AZ_39_J, FWB_AZ_39_K, FWB_AZ_39_L, FWB_AZ_39_M, FWB_AZ_39_N,	Each of the flight line folders contains information on/about; auxiliary, mask, radiance, and Tafkaa.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090522	FWB_QuickLooks_20090522	Contains one JPEG image for each of the flight lines.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090522	Geocorrection	Contains data files with associated ENVI header files for each of the flight paths.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090522	Geoferenced	Contains atmospherically and georeferenced reflectance images of each flight path.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090523	FWB_AZ_317_G, FWB_AZ_317_H, FWB_AZ_317_I, FWB_AZ_317_J, FWB_AZ_317_K, FWB_AZ_317_L, FWB_AZ_317_M, FWB_AZ_337_G, FWB_AZ_337_H, FWB_AZ_337_I, FWB_AZ_337_J, FWB_AZ_337_K, FWB_AZ_337_L	Each of the flight line folders contains information on/about; auxiliary, mask, radiance, and Tafkaa.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090523	FWB_QuickLooks_20090523	Contains one JPEG image for each of the flight lines.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090523	Geocorrection	Contains data files with associated ENVI header files for each of the flight paths.
\TS09_GD\Attribute_Data\HyMap…\Shoalwater_20090523	Geoferenced	Contains atmospherically and georeferenced reflectance images of each flight path.

Table 2. HyMAP Flight Line Center Time. The time displayed is given in Australian Eastern Standard Time (EST).

Flight line	Date	Time of flight line center (EST)
FWB_AZ_39_G	21 May 2009	10:11:02
FWB_AZ_39_H	21 May 2009	10:19:58
FWB_AZ_39_I	21 May 2009	10:28:48
SP_AZ_0_C	21 May 2009	11:45:06
SP_AZ_0_D	21 May 2009	11:51:33
SP_AZ_0_E	21 May 2009	11:57:48
SP_AZ_0_F	21 May 2009	12:04:15
SP_AZ_0_G	21 May 2009	12:10:10
SP_AZ_18_C	21 May 2009	11:32:57
SP_AZ_18_D	21 May 2009	11:26:56
SP_AZ_18_E	21 May 2009	11:20:30
SP_AZ_18_F	21 May 2009	11:14:21
SP_AZ_18_G	21 May 2009	11:07:53
SP_AZ_18_H	21 May 2009	10:56:36
SP_AZ_18_I	21 May 2009	10:50:29
FWB_AZ_39_F	22 May 2009	10:15:38
FWB_AZ_39_G	22 May 2009	10:06:35
FWB_AZ_39_H	22 May 2009	9:57:04
FWB_AZ_39_I	22 May 2009	9:48:09
FWB_AZ_39_J	22 May 2009	9:38:31
FWB_AZ_39_K	22 May 2009	9:29:25
FWB_AZ_39_L	22 May 2009	9:19:36
FWB_AZ_39_M	22 May 2009	9:10:16
FWB_AZ_39_N	22 May 2009	9:00:35
FWB_AZ_317_G	23 May 2009	13:45:30
FWB_AZ_317_H	23 May 2009	13:54:24
FWB_AZ_317_I	23 May 2009	14:03:34
FWB_AZ_317_J	23 May 2009	14:12:56
FWB_AZ_317_K	23 May 2009	14:22:07
FWB_AZ_317_L	23 May 2009	14:31:36
FWB_AZ_317_M	23 May 2009	14:40:41
FWB_AZ_337_G	23 May 2009	12:26:39
FWB_AZ_337_H	23 May 2009	12:57:31
FWB_AZ_337_I	23 May 2009	13:06:23
FWB_AZ_337_J	23 May 2009	13:15:13
FWB_AZ_337_K	23 May 2009	13:24:24
FWB_AZ_337_L	23 May 2009	13:33:48

2. Quicklook Imagery

Figures 1 through 6 show the HyMap imagery as thumbnail-sized quicklooks for each flight day. Note: Quicklook images are not to scale. Information on the weather for Sam Hill is located in Table 3. The time is provided in Australian Eastern Standard Time (EST). The time presented is the time when the image center was captured by the sensor.

FWB_AZ_39_G: 10:11:02 EST

FWB_AZ_39_H: 10:19:58 EST

FWB_AZ_39_I: 10:28:48 EST

Figure 1 May 21, 2009 HyMap Imagery-Freshwater Beach, Azimuth 39, lines G, H, I.. Sky conditions were partly cloudy from 10:00 to 12:00 PM and clear from 12:00 to 2:30 PM. Temperatures ranged from 9.6 to 25.1 ˚C. Relative humidity ranged from 83% at 9:00 AM to 50% at 3:00 PM. Approximately 0.2mm of rainfall was measured at Sam Hill.

SP_AZ_0_C: 11:45:06 EST SP_AZ_0_D : 11:51:33 EST SP_AZ_0_E: 11:57:48 EST SP_AZ_0_F: 12:04:15 EST SP_AZ_0_G: 12:10:10 EST

Figure 2 May 21, 2009 HyMap Imagery-Sabina Point, Azimuth 0, lines C, D, E, F, G. . Sky conditions were partly cloudy from 10:00 to 12:00 PM and clear from 12:00 to 2:30 PM. Temperatures ranged from 9.6 to 25.1 ˚C. Relative humidity ranged from 83% at 9:00 AM to 50% at 3:00 PM. Approximately 0.2 mm of rainfall was measured at Sam Hill.

SP_AZ_18_C: 11:32:57 EST

SP_AZ_18_D: 11:26:56 EST

SP_AZ_18_E: 11:20:30 EST

SP_AZ_18_F: 11:14:21 EST

SP_AZ_18_G: 11:07:53 EST

SP_AZ_18_H: 10:56:36 EST

SP_AZ_18_I: 10:50:29 EST

Figure 3 May 21, 2009 HyMap Imagery-Sabina Point, Azimuth 18, lines C, D, E, F, G, H, I. Sky conditions were partly cloudy from 10:00 to 12:00 PM and clear from 12:00 to 2:30 PM. Temperatures ranged from 9.6 to 25.1 ˚C. Relative humidity ranged from 83% at 9:00 AM to 50% at 3:00 PM. Approximately 0.2 mm of rainfall was measured at Sam Hill.

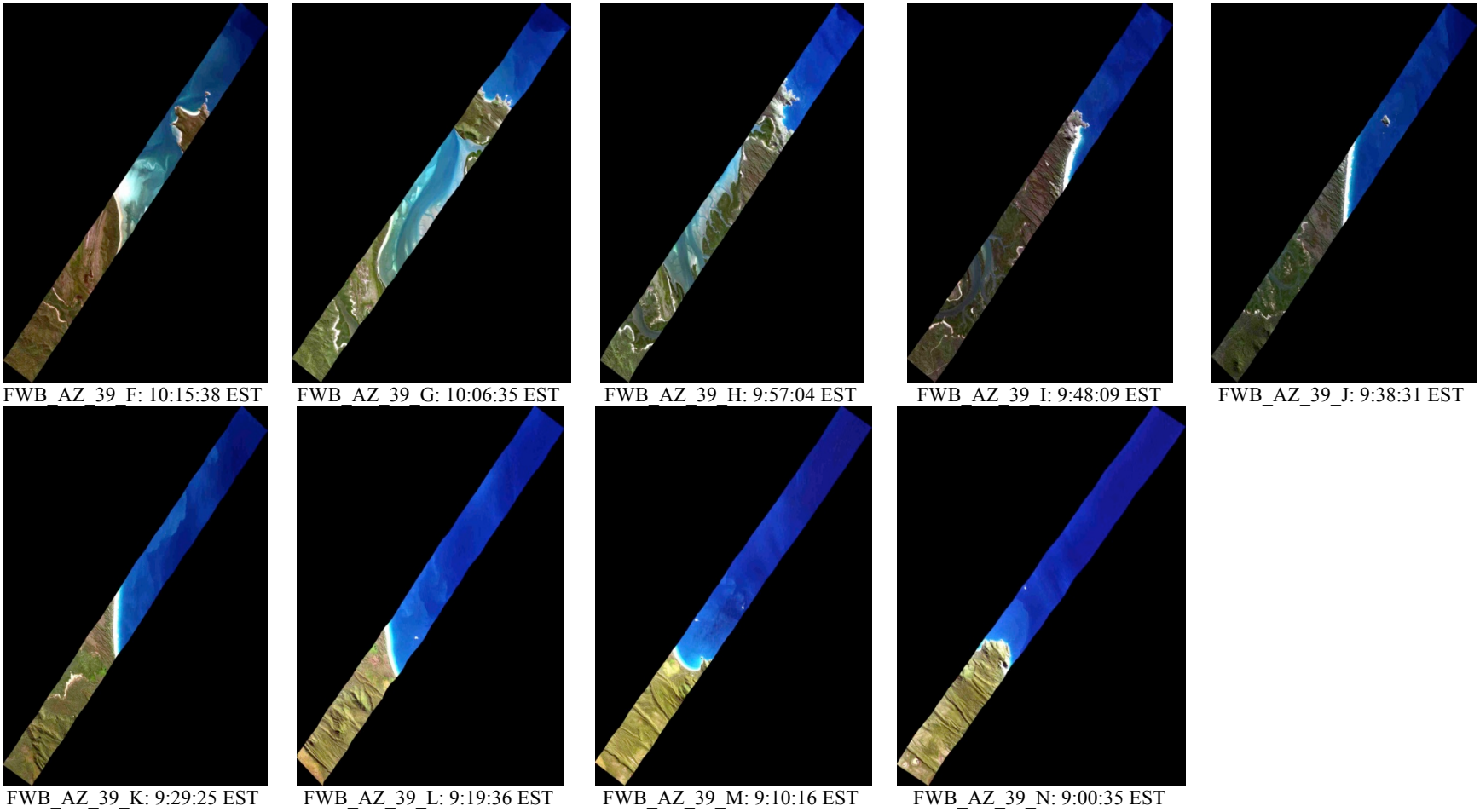


Figure 4 May 22, 2009 HyMap Imagery-Freshwater Beach, Azimuth 39, lines F, G, H, I, J, K, L, M, N. Sky conditions vacillated from partly cloudy to scattered clouds to clear from 10:00 AM to 3:00 PM. Temperatures ranged from 8.6 to 24.2 ˚C. Relative humidity ranged from 74% at 9:00 AM to 49% at 3:00 PM. Approximately 0.8 mm of rainfall was measured at Sam Hill.

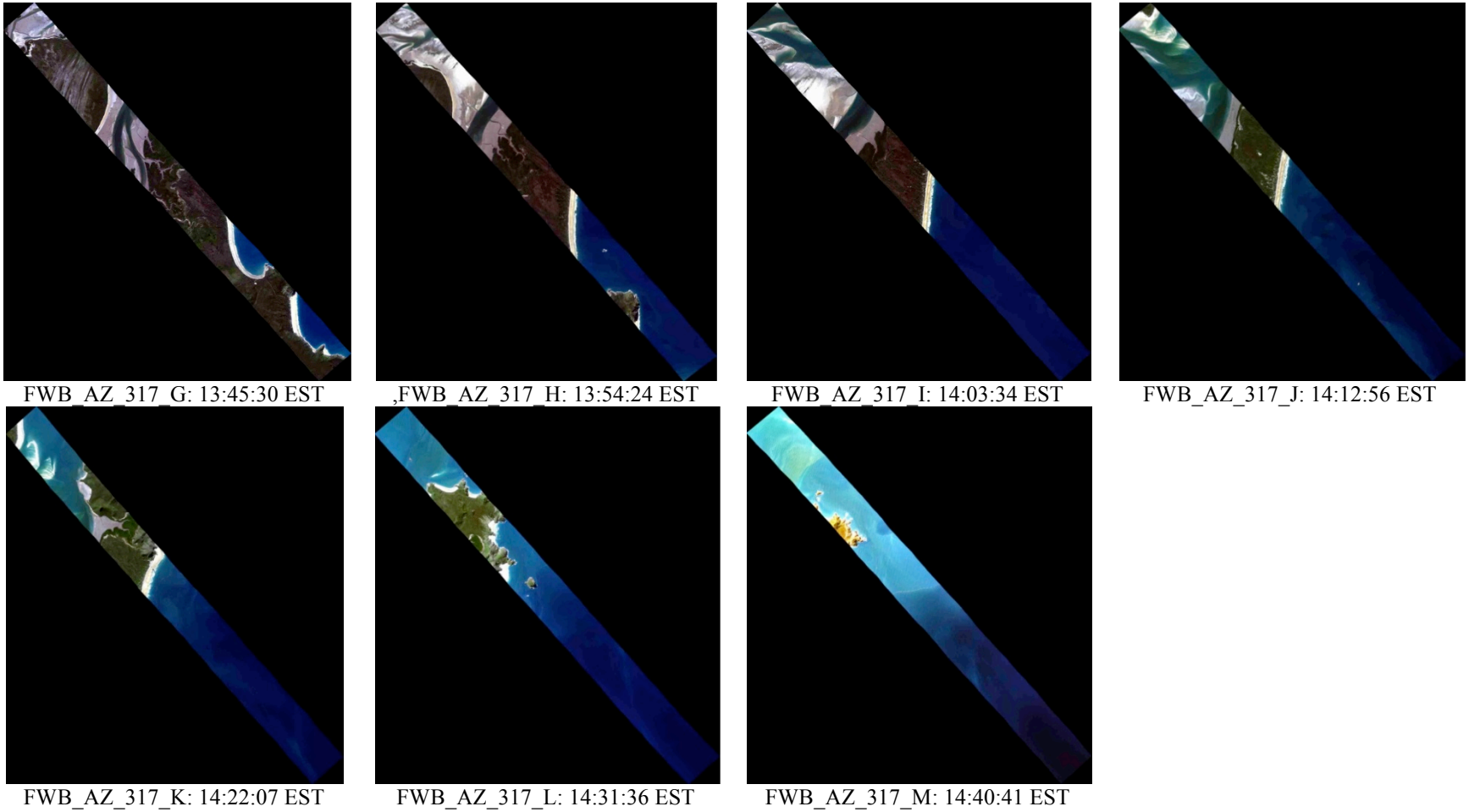
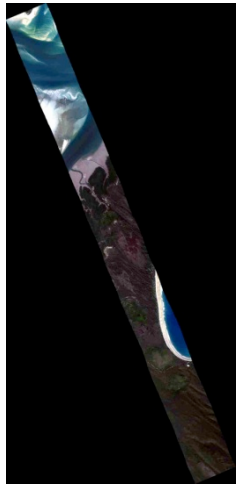
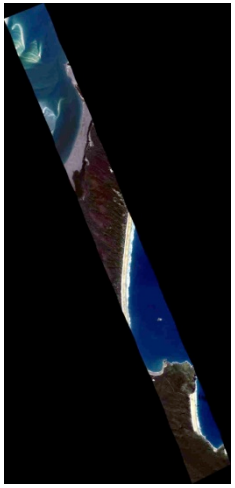


Figure 5. May 23, 2009 HyMAP Imagery-Freshwater Beach, Azimuth 317, lines G, H, I, J, K, L, M. Sky conditions vacillated from clear to partly cloudy from 10:00 AM to 3:00 PM. Temperatures ranged from 7.9 to 25.4 ˚C. Relative humidity ranged from 82% at 9:00 AM to 36% at 3:00 PM. Approximately 0.2 mm of rainfall was measured at Sam Hill.

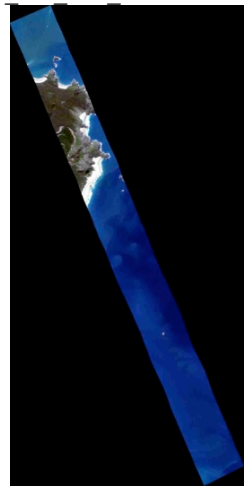


FWB_AZ_337_G: 12:26:39 EST



FWB_AZ_337_H: 12:57:31 EST

FWB_AZ_337_I: 13:06:23 EST



FWB_AZ_337_J: 13:15:13 EST

FWB_AZ_337_K: 13:24:24 EST

FWB_AZ_337_L: 13:33:48 EST

Figure 6. May 23, 2009 HyMAP Imagery-Freshwater Beach, Azimuth 337, lines G, H, I, J, K, L. Sky conditions vacillated from clear to partly cloudy from 10:00 AM to 3:00 PM. Temperatures ranged from 7.9 to 25.4 ˚C. Relative humidity ranged from 82% at 9:00 AM to 36% at 3:00 PM. Approximately 0.2 mm of rainfall was measured at Sam Hill.

Table 3. Daily Weather Observations for Station 033308 sited at Samuel Hill, Queensland for the month of May 2009

Day	Temperature (°C)		Rainfall (mm)	Maximum wind gust			9am					3pm				
	Min.	Max.		Dir.	Spd (km/h)	Time	Temp. (°C)	rh (%)	wind dir.	wind speed (km/h)	MSL pres. (hPa)	Temp. (°C)	rh (%)	wind dir.	wind spd (km/h)	MSL pres. (hPa)
1	11.8	26.2	0	SSE	31	10:00	22	60	SSE	15	1019.5	24.8	44	ESE	17	1017
2	14.5	25.3	2	SE	37	14:14	20.6	95	SSE	15	1020.6	24.1	62	ESE	24	1017.4
3	15.7	25.5	0	SE	39	13:08	22.2	79	SSE	17	1020.8	23.7	60	ESE	22	1019.1
4	13.2	25.2	0	SE	39	19:49	21.3	72	SSE	19	1021.8	23.6	64	SE	17	1019.6
5	17.8	24.9	9.8	SE	50	12:36	22.1	76	SE	22	1022.8	21.3	87	SE	13	1020.7
6	17.8	24.8	1.4	ESE	35	0:50	21.8	74	S	15	1022.2	22.8	67	SE	19	1018.8
7	17.9	23.1	0	SSE	35	9:31	22.7	75	SE	20	1020.4	20	98		Calm	1018.5
8	17.4	24.1	20.8	SSE	43	11:48	20.8	87	S	13	1021.1	23.2	68	SE	20	1019.3
9	18.1	24.3	0.2	SSE	33	10:28	21.1	81	SSE	15	1020.5	23	67	SE	17	1017.7
10	12.2	24.8	0.2	SSE	26	9:15	20.8	95	SE	11	1018.6	22.8	57	ESE	13	1016.1
11	14.7	24.3	0	S	37	11:39	21.9	74	SSE	19	1018.4	21.2	76	SSE	17	1016
12	16.4	23.4	1.2	SSE	35	12:02	19.3	94	SSE	15	1017.8	20.9	79	SSE	13	1015.3
13	16.5	20.8	2.2	SSE	24	10:59	18.1	100	SSE	13	1016.1	20.3	93	SSE	6	1013.6
14	17.6	24.4	4.4	ESE	30	13:48	20.3	97	SSE	11	1015.5	22.4	67	SE	15	1013.6
15	11.6	22.6	0	SSE	22	9:32	21.3	87	SSE	9	1017.8	21.9	72	SSE	9	1015.3
16	9.5	25.5	0.2	SE	22	12:09	18.4	87	S	6	1018.3	24.9	32	E	9	1014.6
17	7.4	24.9	0	SSE	41	9:12	18.1	66	SSE	7	1018.1	23.8	38	ENE	7	1013.9
18	9.6	25	0	SE	28	12:18	19.8	73	SSE	9	1017.3	22.6	68	ESE	13	1014
19	17.2	22.2	2.4	NE	22	16:35	17.8	100	WNW	6	1016.1	20.5	99	SE	9	1011.2
20	15.1	25.7	10.4	W	22	12:55	17.7	100	SW	7	1012	24.9	47	WSW	7	1007.6
21	9.6	25.1	0.2	WSW	22	19:08	17.9	83	SSW	4	1010.1	23.7	50	WNW	6	1006.5
22	8.6	24.2	0.8	SE	20	12:10	17.5	74	W	9	1010.5	22	49	S	7	1007.3
23	7.9	25.4	0.2	W	24	14:30	17.5	82	SSE	6	1012.4	25.1	36	SW	13	1008.4
24	12.1	22.9	0	SSE	46	17:00	20.4	80	SSE	15	1015.8	21.2	90	SE	20	1014.5
25	16.3	23.7	3.2	SE	37	10:08	21.7	76	SE	20	1019.8	22.5	62	SE	19	1017.7
26	16.6	22.5	1	SE	28	15:41	17.5	99	SSE	13	1020.8	21.4	77	SE	15	1017.8
27	15.7	22	15.4	E	26	14:13	18.4	100	SE	7	1019.5	21	70	SE	15	1016.6
28	13.2	24.4	3.4	ESE	24	15:00	20	88	SSE	13	1019.7	22.7	65	ESE	15	1016.5
29	11	24.9	0	SE	22	11:17	19.2	94	SSE	9	1019.6	24.3	58	ESE	9	1017.4
30	11.5	24.7	0	E	28	12:23	19.1	100	S	6	1021.1	23.5	71	ESE	15	1019.2
31	16.7	23.9	1.6	E	41	11:53	20.8	85	SE	17	1023.7	21.3	76	SSE	17	1021.2

APPENDIX D

Geodatabase

---

1. Introduction

A geodatabase is an information database that contains data with a geographical component. It is a collection of feature data for use within a GIS package such as ArcMap or ArcGIS Explorer. ArcMap is contained in ArcGIS and is a proprietary software program developed by Environmental Systems Research Institute, INC (ESRI). ArcGIS Explorer is a free software version of ArcGIS which was developed by ESRI and is used mainly for visualization and presentation purposes. The software program is similar to Google® Earth and can manipulate and render shapefiles. It also allows the user to add points and shapes to the viewer, but creating and editing shapefiles is not possible in this version. The structure of the TS'09 geodatabase allows it to be viewed in both ArcGIS and ArcGIS Explorer. The ArcGIS Explorer version was developed in order to accommodate those users who might want to see the positions and type of data collected but do not have access to ArcGIS. Those with access to ArcGIS and the applications of ArcMap, ArcToolbox, and ArcCatalog will have access to the full capabilities of the geodatabase and be able to create and edit data to suit their individual needs.

The ArcGIS Explorer 900 version is available on the geodatabase drive at the path \ArcGIS_Explorer_Program. To download the program, the Microsoft .NET Framework 2.0 Service Pack 1 must be downloaded first (also included on the geodatabase drive). After installation of the Microsoft .NET update, the ArcGISExplorerDownload.exe file can be executed. The ArcGIS Explorer 900 program can also be downloaded from ESRI's website at the URL: http://www.esri.com/software/arcgis/explorer/download.html.

To view the geodatabases, navigate to either the *.mxd* or *.nmf* file in the VCR_GD folder in Windows Explorer. By opening the *.mxd* file, the ArcMap (ArcGIS) version of the geodatabase is opened. Clicking the *.nmf* file opens the ArcGIS Explorer 900 version.

The following sections describe the information that it is included on the geodatabase drive, and basic access of data in the two GIS versions.

2. Geodatabase Drive

Navigating the geodatabase drive through Windows Explorer displays the available folders in the TS'09 geodatabase. Figure 1 displays the folder hierarchy that was designed for the TS'09 database. In the figure, the TS'09 database (TS09_GD) contains seven folders (Attribute Data, GIS Data, Metadata, Misc, Products, TS09_GD.gdb, and User Manual Information) and three files (TS09_ALL Data.xls, TS09_ArcGDBS.mxd, and TS09_GD_Explorer.nmf) at the top level. The Attribute Data folder contains sub-folders of each type of data collected during the TS'09 campaign. Most folders contain tabular data for each day that data were collected. The tabular information is combined into *TS09_ALL_DATA.XLS* with each tab containing different types of data. In the Attribute Data folder, non-tabular data are mainly contained in the folders HyMap and Multimedia. These two folders contain raster images that can be opened via ITT's ENVI and Microsoft® Windows Picture and Fax Viewer, respectively. The GIS Data folder contains the ArcGIS Explorer 900 program and associated files, *KML/KMZ* files used for interoperability with Google® Earth, *mxd* files, raster files, and various shapefiles. The raster files and shapefiles in the GIS Data folder are files which have been gathered from multiple sources or created from the TS09 attribute data. Files residing in these folders are the preliminary shapefiles/rasters which have not been exported into "gdb" file format via ArcCatalog. The Metadata folder contains FGDC documentation about shapefile, raster, and geodatabase creation. The Misc folder contains miscellaneous files. The Products folder contains raster, and text products created from the attribute data. The data report resides in the Text subfolder of the Products folder. The User Manual Information folder contains documentation about retrieving data and navigating the database and geodatabase. When navigating via Windows® Explorer the TS09_GD.gdb (File Geodatabase) appears as a folder, but when navigating via ArcCatalog the TS09_GD.gdb appears as a geodatabase icon. The format of the TS09_GD.gdb is a File Geodatabase.

Viewed below Figure 1, Table 1 presents the attribute data collected during the TS'09 field campaign. This can be used as a guideline for accessing data in the TS'09 geodatabase. Each data type is listed along the left hand side with each day listed across the top. Abbreviations are used to make viewing easier and the abbreviation key is listed in the caption above the table.

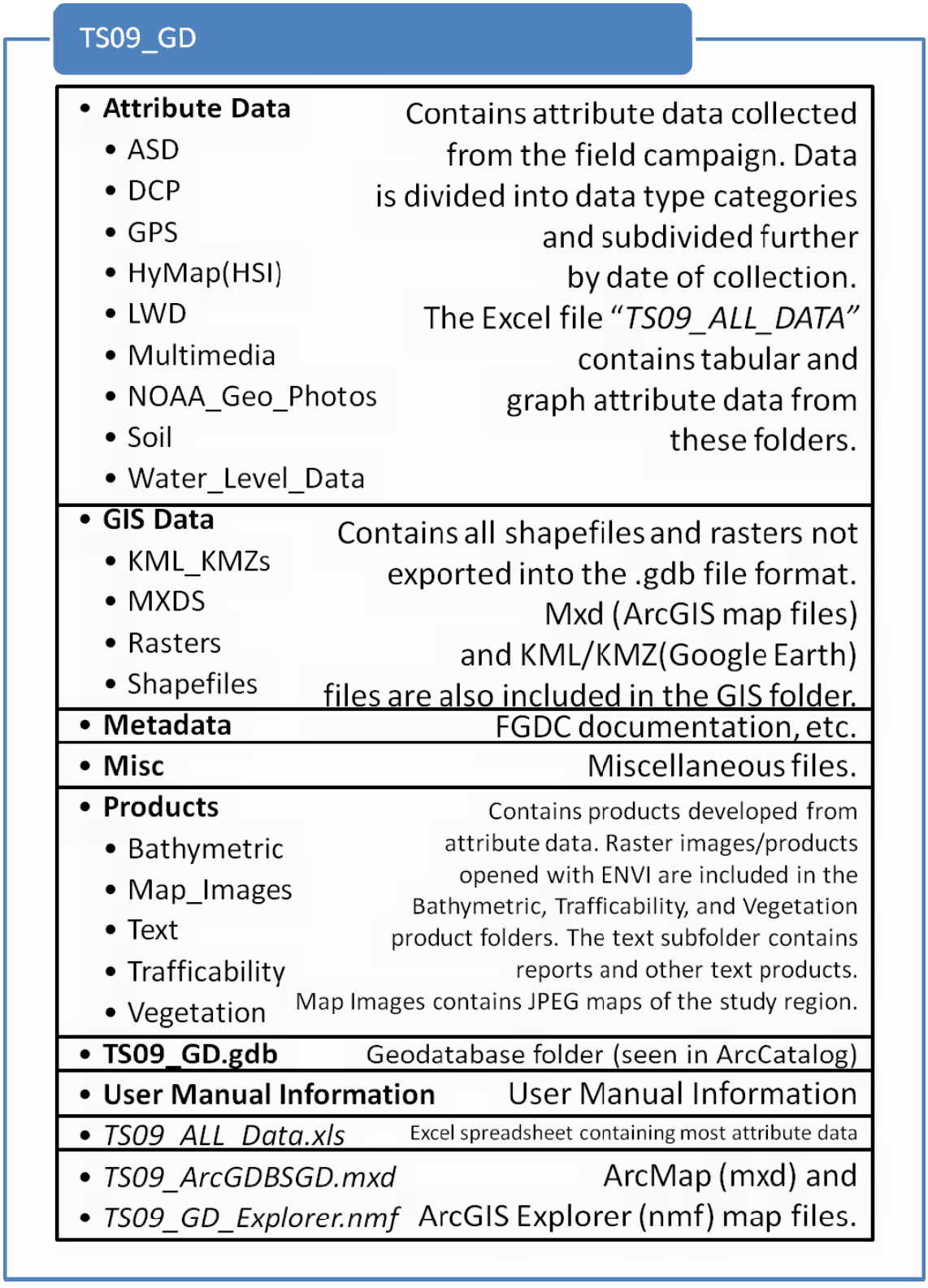


Figure 1. Typical organization of data on drive. Top level folders are shown in bold, while sub-folders are shown with non-bold type. Italicized names indicate files. Descriptions of each folder/file are listed on the right hand column.

Table 1. TS09 Attribute Data Collection Locations: Abbreviations: CCPB = Cape Clinton Pocket Beach; FWB= Freshwater Beach; SP= Sabina Point; SAE=Southern Arm Estuary; SH= Sam Hill Vicinity;N/A= Not Applicable; NRL1= Unit 1 Camera from NRL; NRL2= Unit 2 Camera from NRL; P= Personal Camera is used.

Data		19 May	20 May	21 May	22 May	23 May	25 May	26 May	27 May	28 May	29 May
ASD	Site	N/A	FWB	FWB	FWB	SP	N/A	N/A	N/A	CCPB	N/A
	Leaf Optics	N/A	N/A	N/A	N/A	N/A	N/A	N/A	SH, FWB (Leaf Collection)	SH	SH
	Local Feature/Leaf (In Situ)	N/A	N/A	N/A	FWB	SP	SAE	N/A	N/A	N/A	SH
	Calibration Panels	N/A	N/A	Parking Lot @ FWB	Parking Lot @ FWB	N/A	N/A	N/A	N/A	N/A	N/A
	Shallow water Bathymetry	N/A	FWB	FWB	FWB	SP	SAE	N/A	N/A	CCPN	N/A
DCP		CCPB	FWB	FWB	FWB	SP	N/A	N/A	N/A	CCPB	N/A
Ground Control Points		SH	N/A	N/A	FWB(Tarps)	N/A	N/A	N/A	N/A	N/A	N/A
GPS	Sites	CCPB	FWB	FWB	FWB	SP	N/A	N/A	SH, FWB	CCPB	SH
	Soundings	N/A	N/A	N/A	FWB-Bay	SP	SAE	N/A	CCPB, FWB, FWB Bay	CCPB	N/A
	Kinematic	CCPB	FWB	FWB	FWB	SP	?	N/A	N/A	N/A	N/A
	Base Station	FWB	FWB	FWB	FWB	SP	FWB	N/A	FWB	N/A	N/A
HYMAP		N/A	N/A	FWB, SP	FWB	FWB	N/A	N/A	N/A	N/A	N/A
LWD		CCPB	FWB	FWB	FWB	SP	N/A	N/A	N/A	FWB	N/A
Multimedia-Location, (Camera Used)		CCPB, (NRL1, P)	FWB, (NRL1, P)	FWB, (NRL1, P)	FWB, (NRL1, NRL2, P)	SP, (NRL2, P)	SAE, (NRL1)	SH, (NRL2, P)	SH, FWB,(NRL1)	CCPB, (NRL1,P); SH, (NRL2)	SH, (NRL2)
NOAA_Geotagged Photographs		FWB	N/A	N/A	N/A	SP	N/A	N/A	N/A	N/A	FWB
Soil		CCPB	FWB	FWB	FWB	SP	N/A	N/A	N/A	CCPB	N/A
Tide Buoy		N/A	FWB	FWB	FWB	SP	SAE	N/A	SAE, CCPB, FWB	CCPB	N/A

3. ArcGIS Explorer Version-Navigation and Data Access

The ArcGIS Explorer version permits the visualization and presentation of data collected during TS'09. Content in this version includes data collected during TS'09 as well as additional data provided by multiple sources. The viewer of ArcGIS Explorer 900 can be seen in Figure 2. The display is similar to ArcMap which has "Tools" along the top, and a "Contents" section which displays the available layers presented in the "Map View" section. The ArcGIS Explorer 900 "Tools" section has similar tabbed navigation as the Microsoft® Office 2007 series.

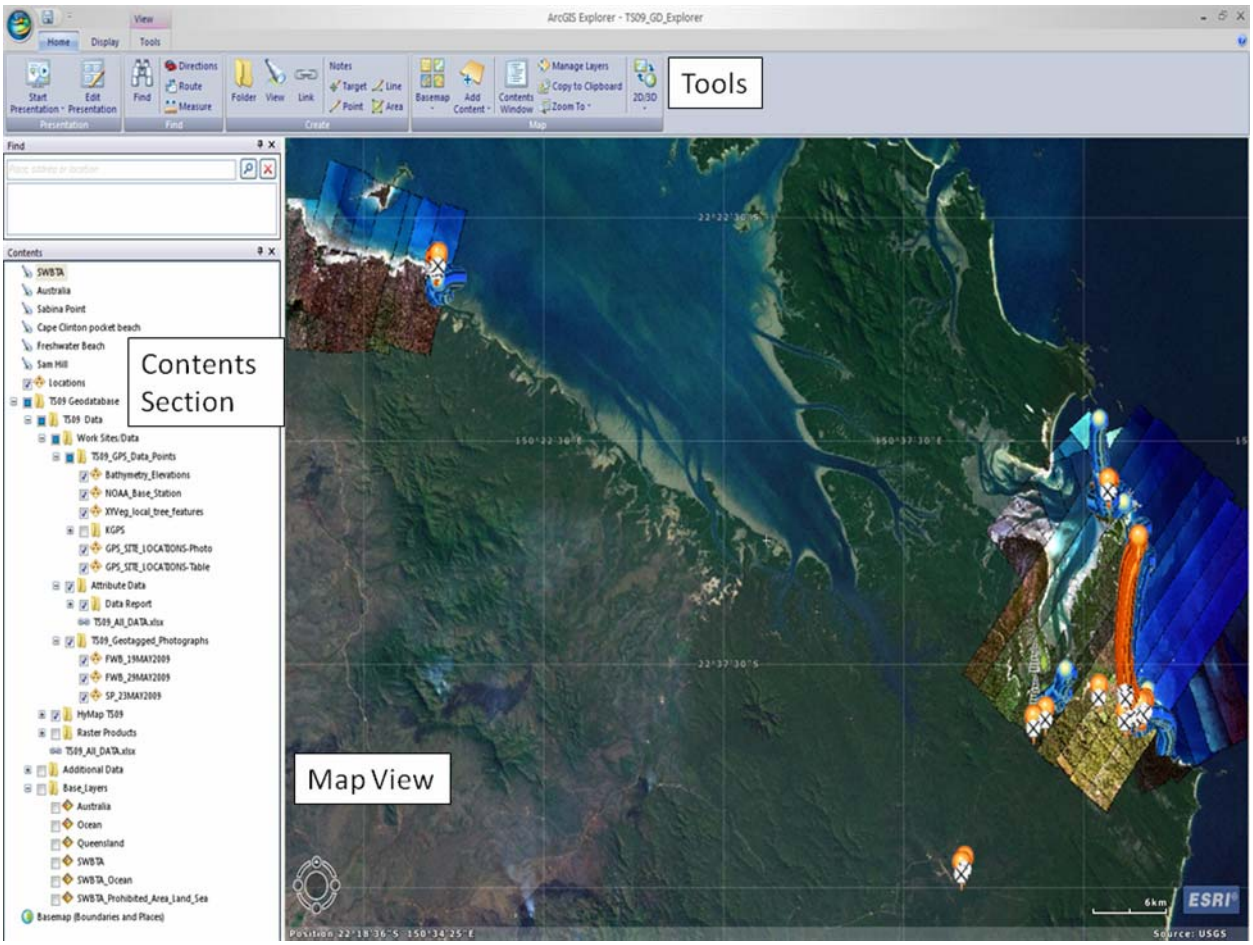


Figure 2. Sections of ArcGIS Explorer 900.

Figure 3 displays the items in the contents view of the ArcGIS Explorer version. The data from the TS'09 campaign is divided into three major sections. The "TS09_Data" section contains the data collected at the site by the NRL team and products developed from this data; the "Additional Data" section contains data obtained from multiple sources, all of which may be applicable for TS'09 product development. The "Base Layers" section contains background shapefiles for viewing; this section is especially useful if an internet connection cannot be obtained (ArcGIS Explorer imagery background "basemap" will not be available).

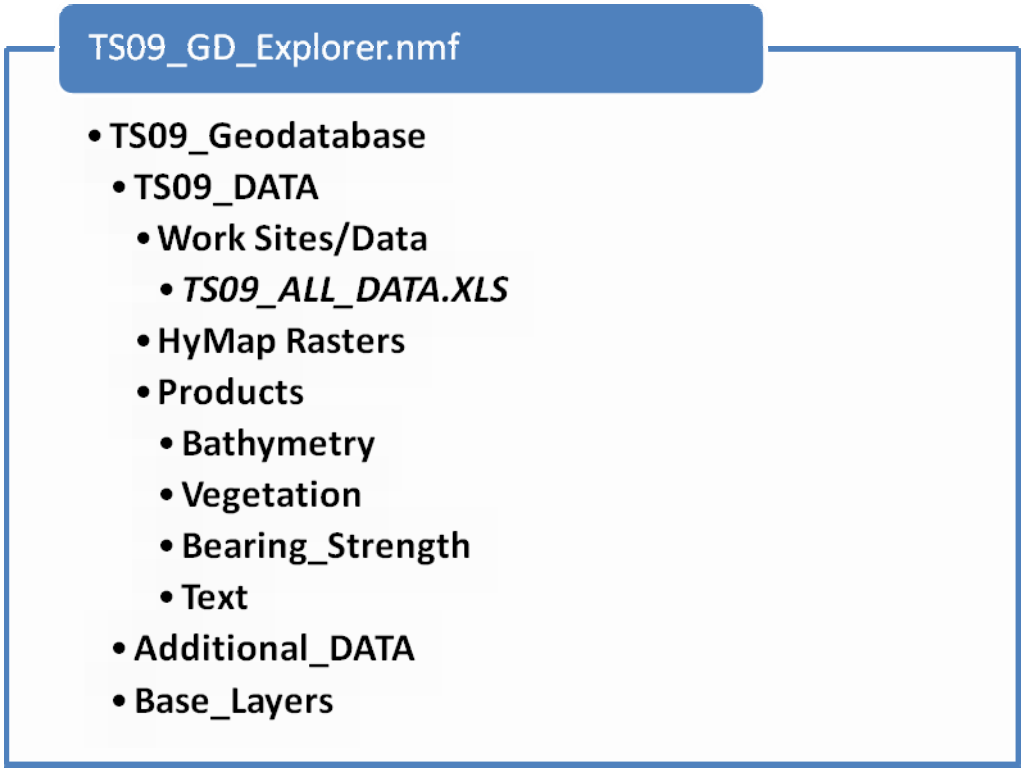


Figure 3 ArcGIS Explorer geodatabase shapefile groupings.

Figure 4 displays a screen capture of the TS'09 GPS data and HyMap imagery. In the figure, red dots signify the GPS points where ground data were collected while HyMap imagery is seen as overlapping images from contiguous flight tracks. The types of data can be turned off or on (viewed or not viewed) by checking or unchecking the box in the "Contents" section.

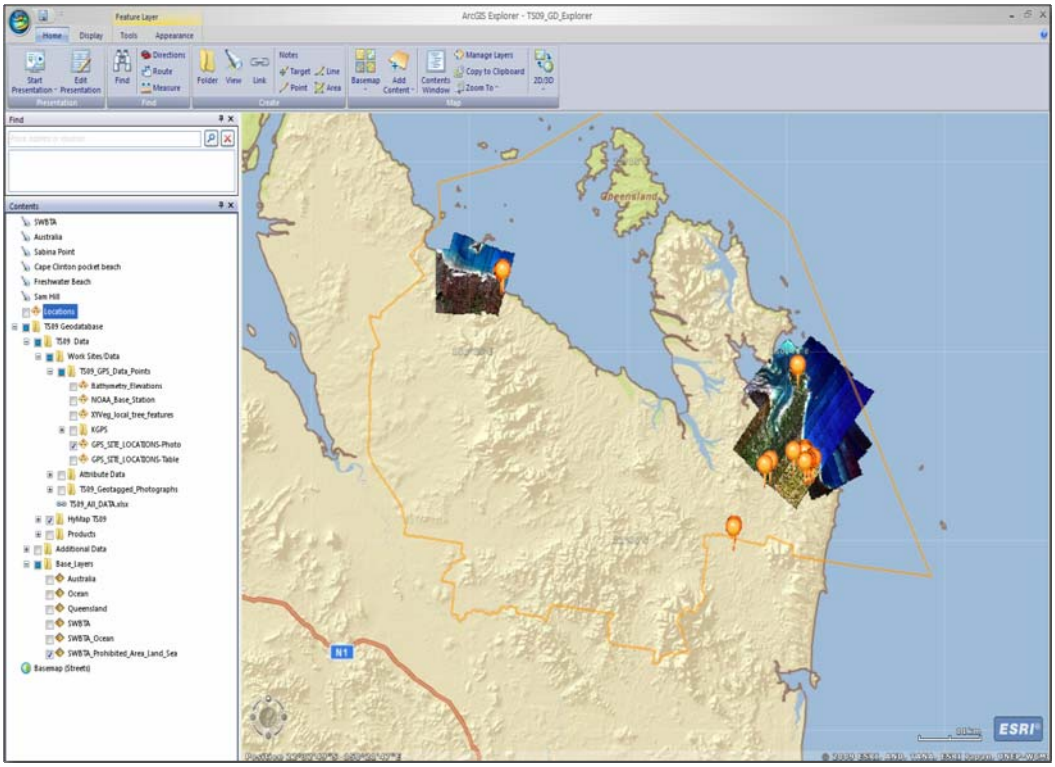


Figure 4. Screen capture of the TS'09 geodatabase viewed in ArcGIS Explorer 900. Display of GPS shapefile (red dots) with HyMap imagery displayed overlapping shapefile.

Figure 5 displays four screen captures depicting the access of GPS attribute data collected during the TS'09 campaign. The top left portion of the figure (marked A) shows a screen capture of the Sabina Point region with the GPS_SITE_LOCATIONS-Photo (red dot), GPS_SITE_LOCATIONS-Table (crosshair circle), BATHYMETRY_ELEVATIONS (blue dot) and SP_23_MAY_2009 (green dot) shapefiles being displayed. Clicking on a shapefile point will trigger a pop-up window displaying either tabular information or a photograph. There are two shapefiles that display the GPS_SITE_LOCATIONS points in the viewer and this is done to access a photograph (B in Figure 5) and attribute information (marked C in Figure 5) associated with the point that is clicked. The attribute information shows the site's name, position, time and date, locality, absolute file pathnames/relative pathnames connecting to a photograph of the site, and a link to the attribute data for all sites. One can access attribute data collected during the TS'09 field campaign by clicking the link icon for "TS09_ALL_DATA.XLS" in the contents section of ArcGIS Explorer (marked D in Figure 5).

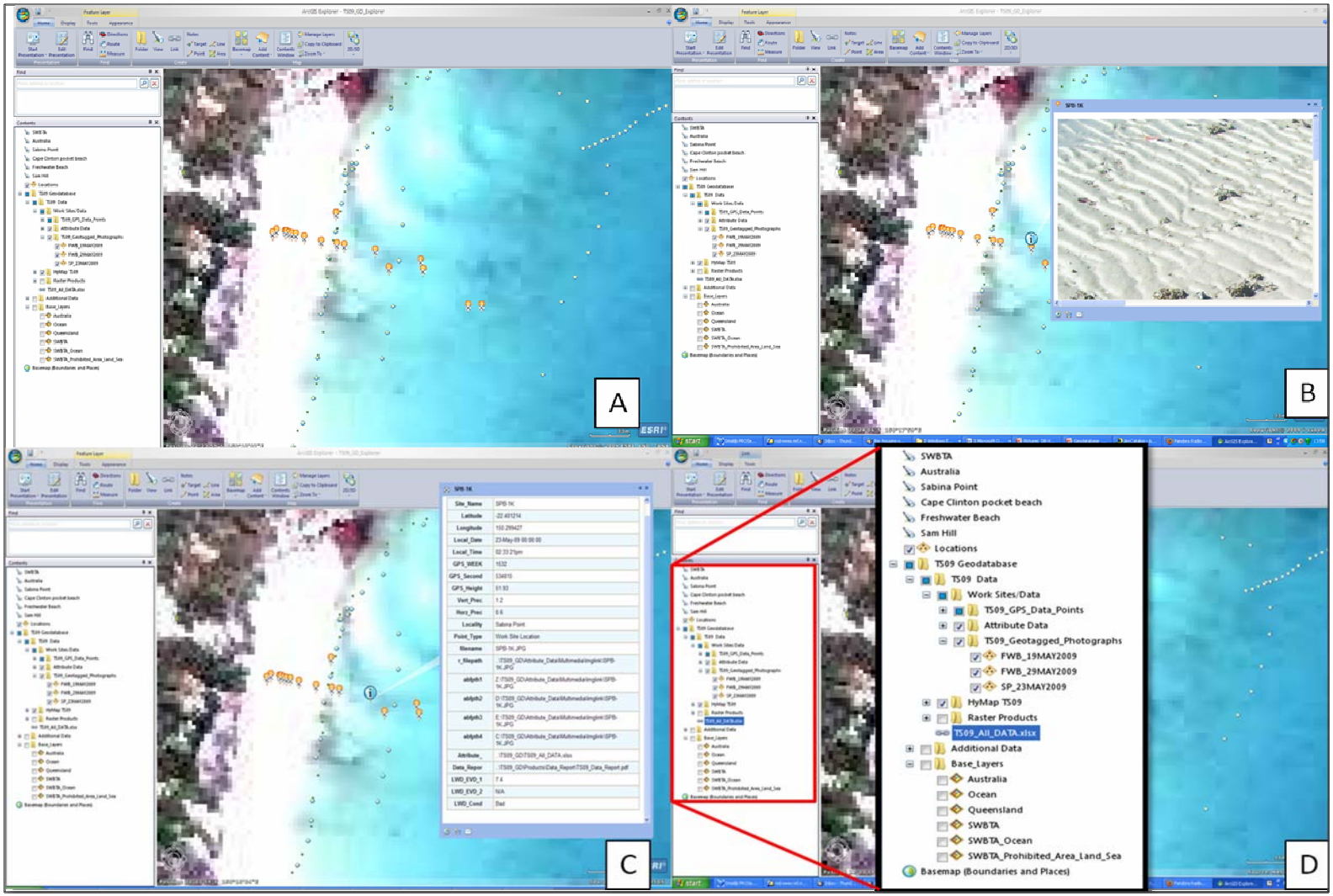


Figure 5. Data access via ArcGIS Explorer. (A) Screen capture of Sabina Point area showing various shapefiles and HyMap Imagery (base image). (B) Clicking on GPS point (red dot) opens photo. (C) Clicking on GPS crosshair icon opens tabular attribute information for that point. (D) Clicking on link to "TS09_ALL_DATA.xls" opens that spreadsheet in another window.

4. ArcGIS Desktop (ArcView) Version- Navigation and Data Access

The ArcGIS Desktop version allows users to manipulate and edit datasets as well as view the data. Figure 6 displays a screen capture of the ArcMap version of the geodatabase with sections of the ArcMap interface that are labeled. The "Table of Contents" section displays the data available for viewing in the "Map Viewer Section." The "Data Frame" contains all the layers that will be seen in the "Map Viewer." "Layers" represent geographic data, usually grouped in a single theme of shapefiles or rasters. A "shapefile" is a non-topological format for storing the geometric location and attribute information of geographic features and is comprised of the individual components that describe the theme in a "Layer." Shapefiles can represent point, line, or area (polygon) vector files and can be turned off from viewing in the "Map Viewer" by checking the box at the side of the shapefile's name in the "Table of Contents" section. The "Menu Bar" is located at the top of ArcMap and contains drop down menus. The "Tools" toolbar contains basic navigational tools used for navigation in the "Map Viewer." The "ArcToolbox Window" allows the more advanced user to gain access to tools to edit the data.

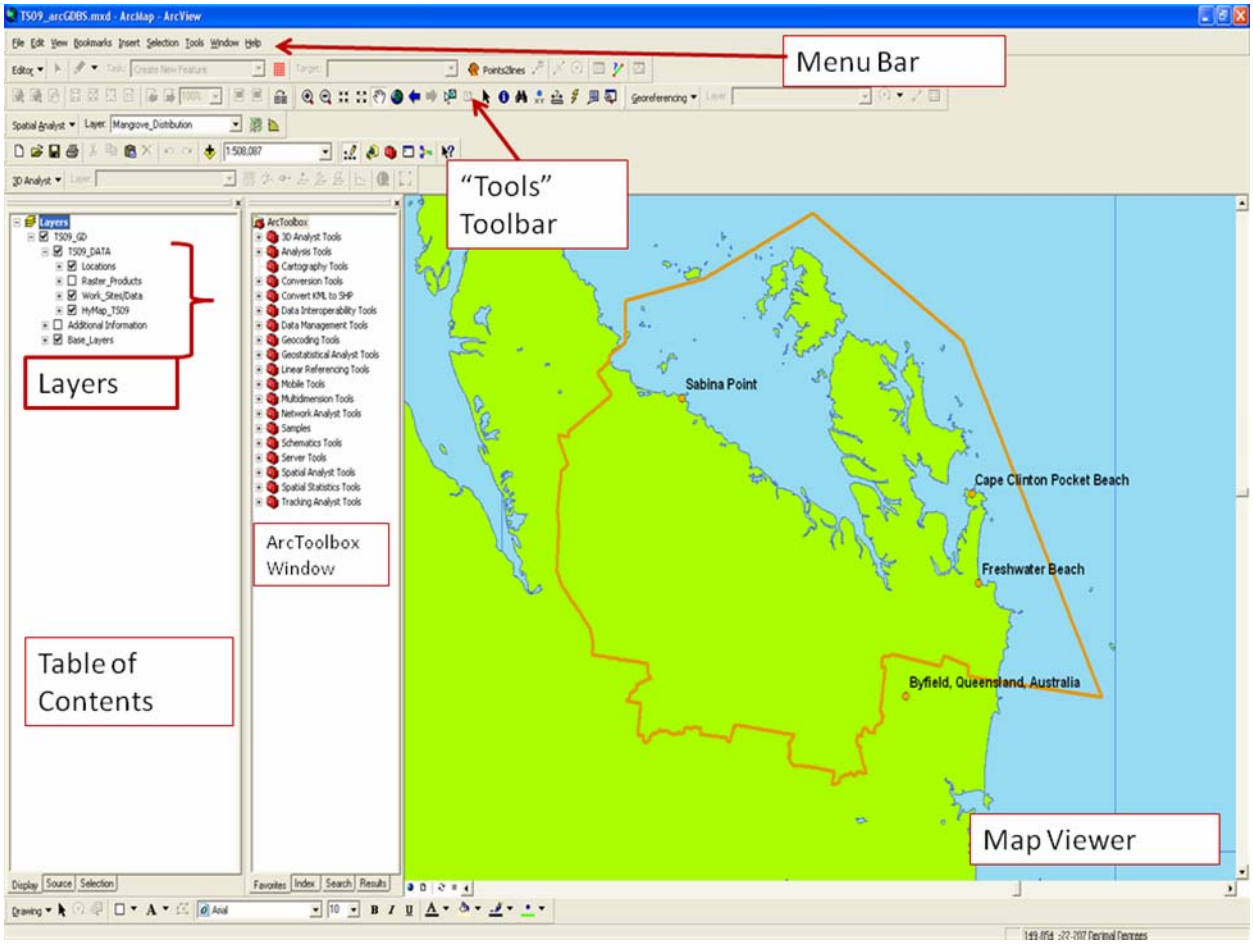


Figure 6. General sections of ArcMap.

Figure 7 displays the data groupings seen in the "Table of Contents" section of ArcMap. The data from the TS'09 campaign is broken down into three major sections. The "TS09_Data" section contains the data collected at the site by the NRL team and products developed from this data; the "Additional Data" section contains data obtained from multiple sources that complements the data collected during the TS'09 experiment; and the "Base Layers" section contains background shapefiles for viewing. The ArcMap version is similar to the ArcGIS Explorer version; however, text products and attribute data are not linked in this version as they are in ArcGIS Explorer.

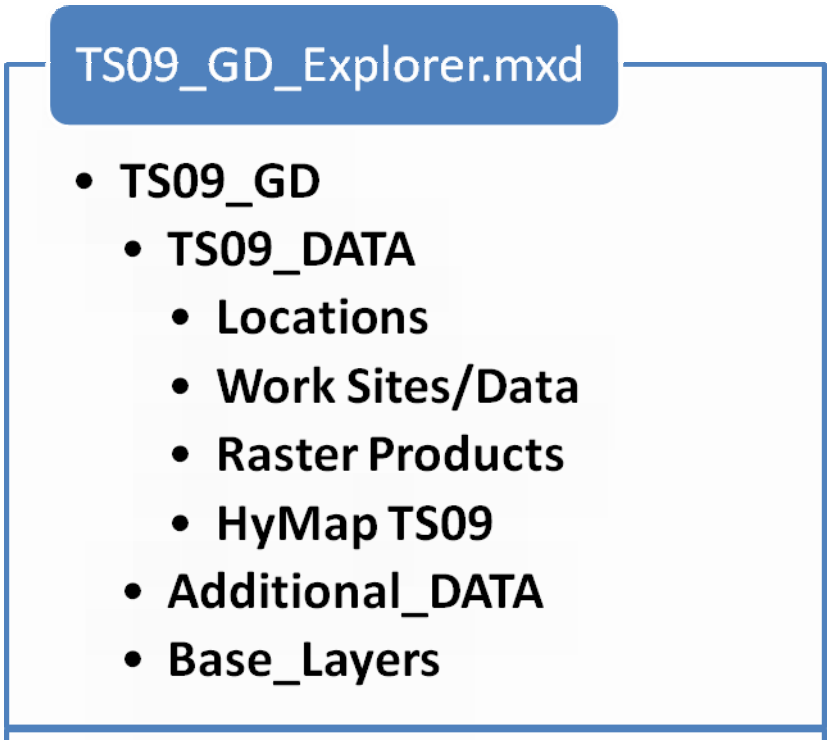


Figure 7. ArcMap geodatabase data groupings.

By using the identify feature tool, one can view attribute data of each shapefile. Figure 8 shows various data available when one clicks GPS_SITE_LOCATIONS point shapefile. In the figure, box A shows the pop-up information that appears when one clicks on yellow hyperlink icon for "ab_fpath..."(photograph link). The yellow lightning bolt represents a hyperlink to a URL, photograph, document, or Excel spreadsheet. Box A shows the pop-up of the photograph linked to that work site. When the hyperlink to the data report is clicked, an associated data report from the TS'09 experiment is displayed in another window. Box C displays an Excel spreadsheet which contains all attribute data collected at the site. One can also navigate through Windows ® Explorer to access the attribute data which is hyperlinked above.

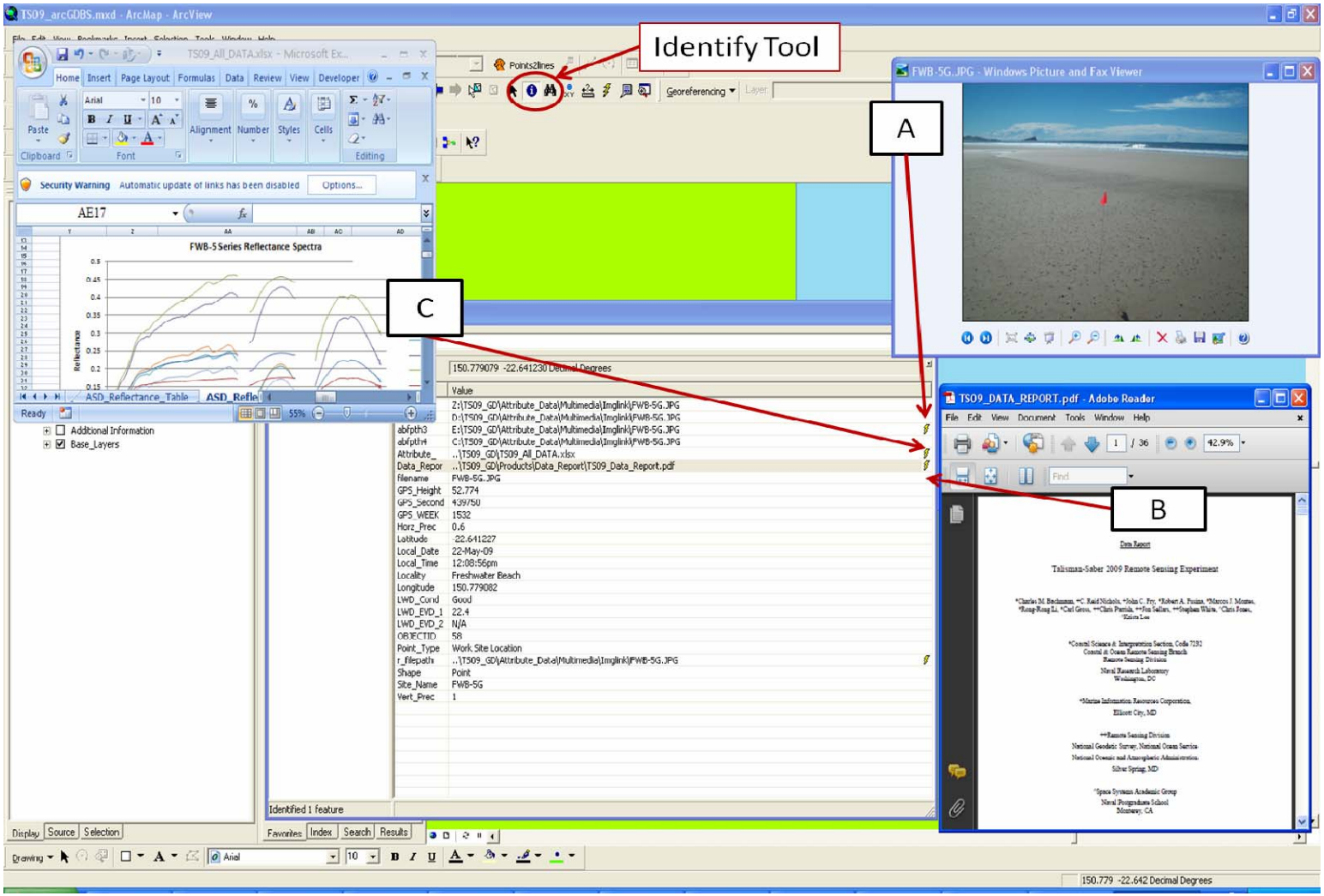


Figure 8. Using the identify feature tool to access GPS work site attribute data. (A) Site photograph accessed via hyper-linking; (B) Data Report accessed via hyperlinking; (C) TS09_ALL_DATA.xls file (Attribute data collected during campaign).

APPENDIX E

Spectra

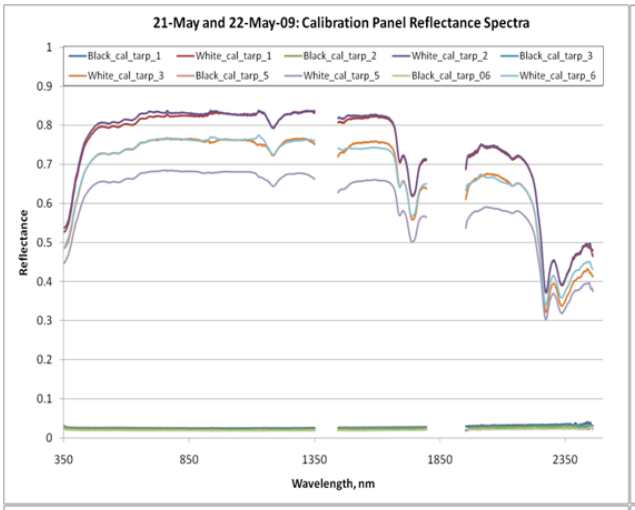
1. Introduction

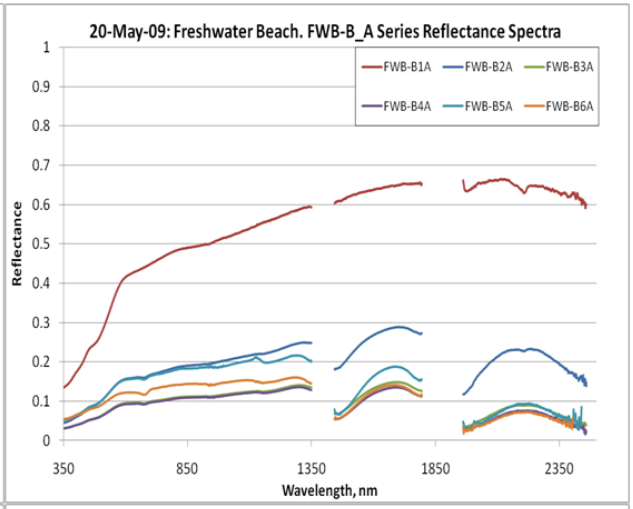
In situ spectral reflectance data were measured with four Analytical Spectral Devices (ASD) portable field spectrometers covering the spectral range from 0.35 to 2.5 μm. Spectra measured with the ASD spectrometers in the field used passive solar illumination and a fiber-optic probe to collect light. The solar zenith incidence angle was variable but typically ranged from 40 to 60 degrees. Spectra were corrected to absolute reflectance by comparison against a Spectralon white reference standard. Field spectra have been collected under various sky conditions. Most were collected under optimum conditions of clear skies and within the range of solar zenith angles listed above. Because of limited time for field work, some spectra were collected under partly cloudy skies and less than optimal solar zenith angles. On days with variable cloud conditions, a dual spectrometer method was employed which allowed simultaneous recording of the white reference and the specimen of interest. The spectra were edited to eliminate spectral regions with very high atmospheric water vapor absorption; these regions have low digital number counts and ratios between the spectral response of the white plaque and the specimen are often unstable in these spectral regions. The regions of editing were roughly from 1.35 μm to 1.44 μm, 1.79 μm to 1.95 μm and 2.45 μm to 2.5 μm. Data from cloudy days using the dual spectrometer method revealed a slight spectral miscalibration between the pairs of spectrometers used. Data in our NRL cal facility has been taken subsequently to determine the spectral shift, and data collected in the field simultaneously from white reference plaques by the two spectrometers were used to generate a transfer function and correct for the small relative shift between the two spectrometers when dual mode data collection was necessary to due to sub-optimal sky conditions.

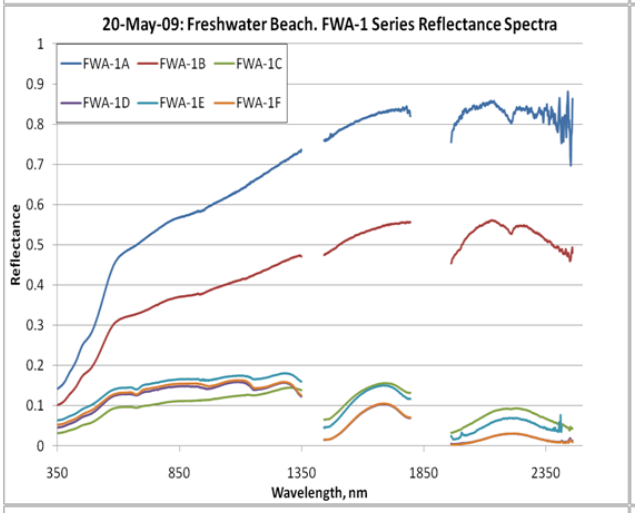
Spectra measured in the lab using the leaf optic apparatus used a light source internal to a contact probe. The contact probe is an accessory for the FieldSpec spectrometer, designed for sampling a small area using only internal illumination from a light source in the contact probe. The leaf optic apparatus is another extension to the ASD FieldSpec.

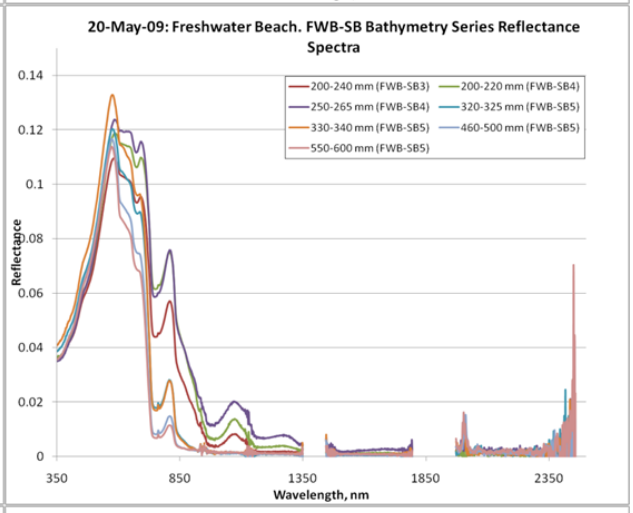
The digital spectral library data is a component of the geodatabase. In the following sections, reflectance spectra, site photographs, and comments about the spectral data are displayed. Reflectance spectra are viewed in Section 2 and are listed in chronological order with the exception of the graph for the calibration panels which is listed first. In the graphs, the *x*-axis displays the wavelength (in nm) and the *y*-axis displays the reflectance value. Photographs of the locations where spectra were collected are presented in Section 3. These photographs are listed in chronological order. The field notes associated with spectral data collection are listed in Section 4, and these appear in chronological order.

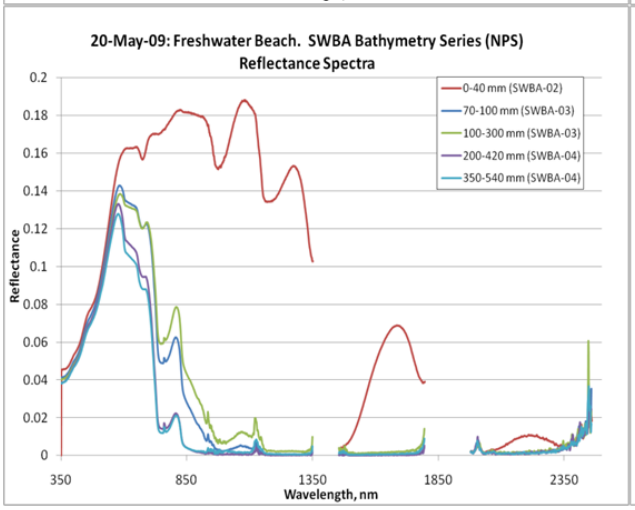
2. Reflectance Spectra

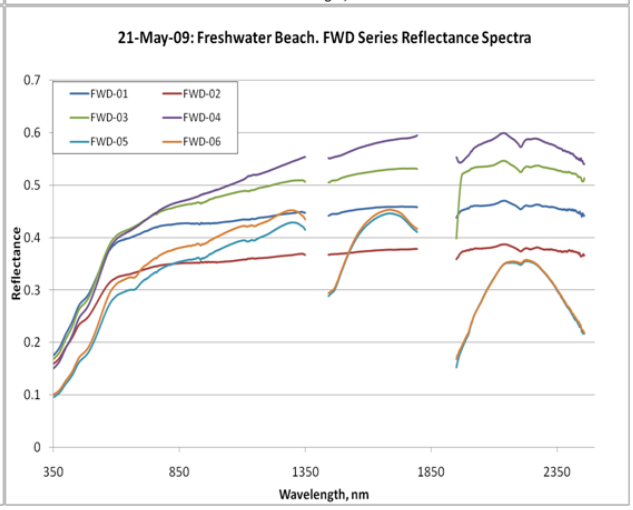


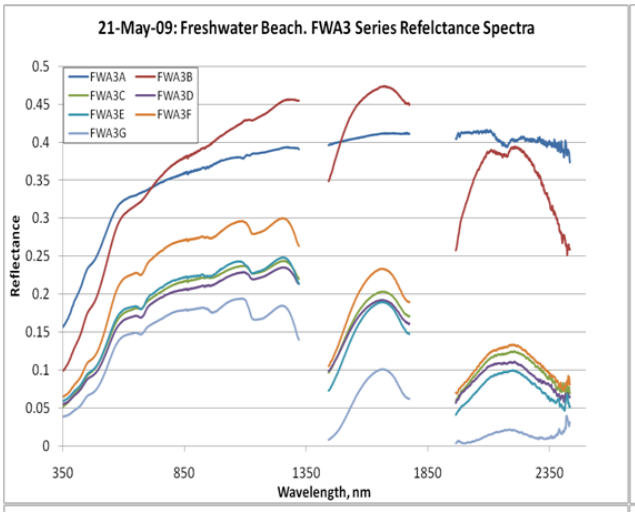


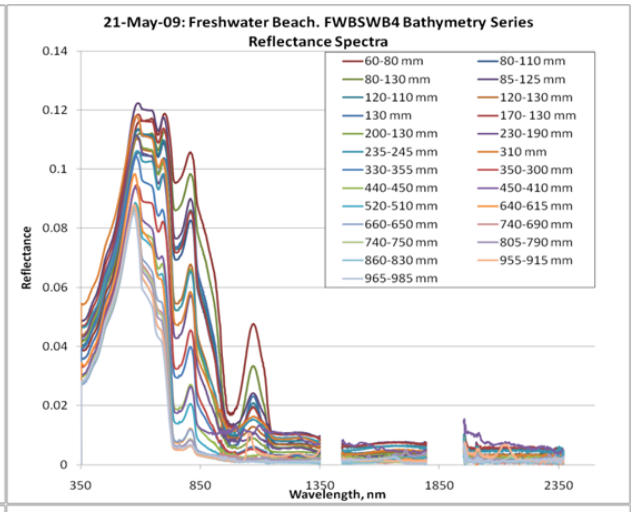


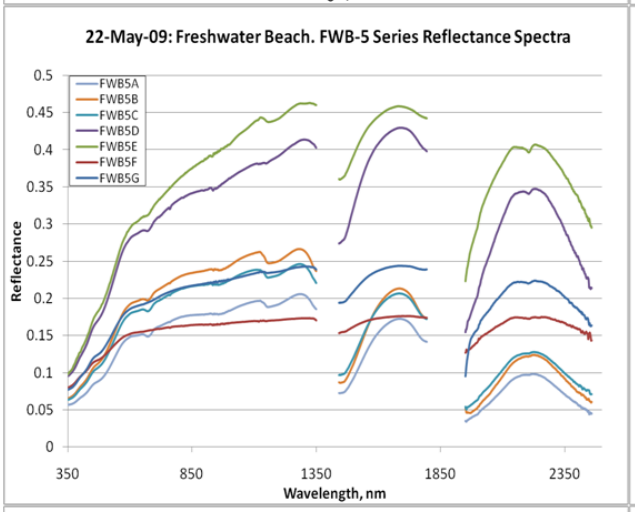


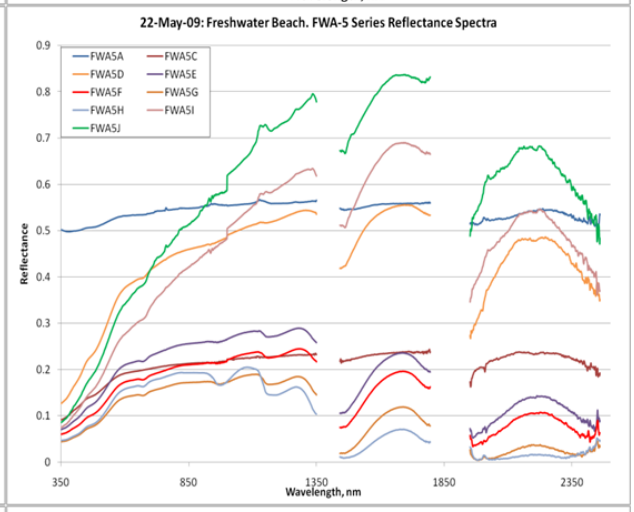


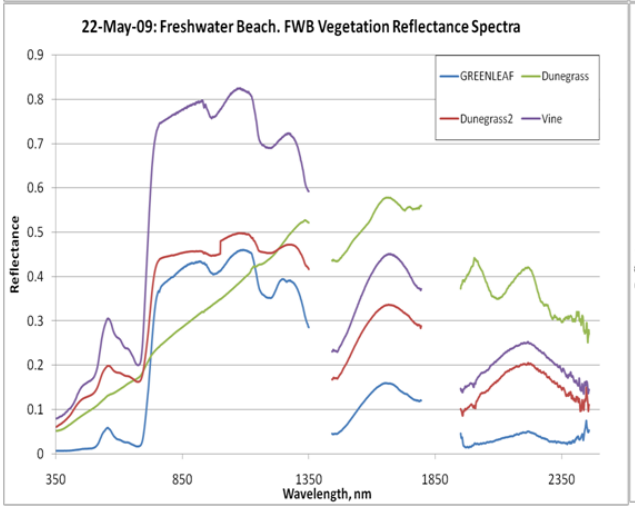


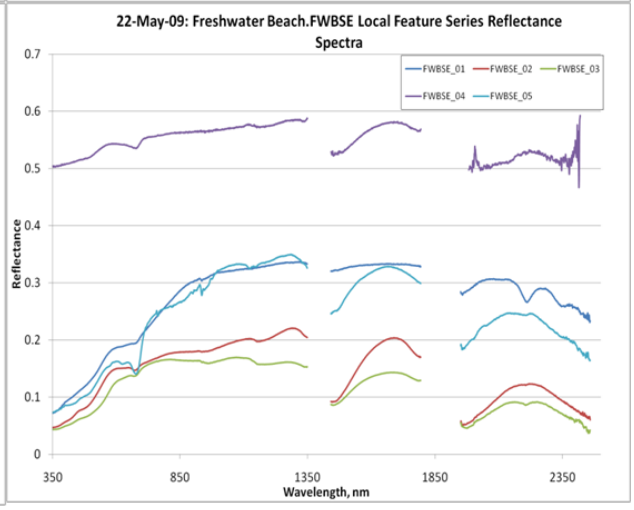

21-May-09: Freshwater Beach. FWA3 Series Refelctance Spectra
FWA3A
FWA3B
FWA3C
FWA3D
FWA3E
FWA3F
FWA3G
Reflectance
Wavelength, nm

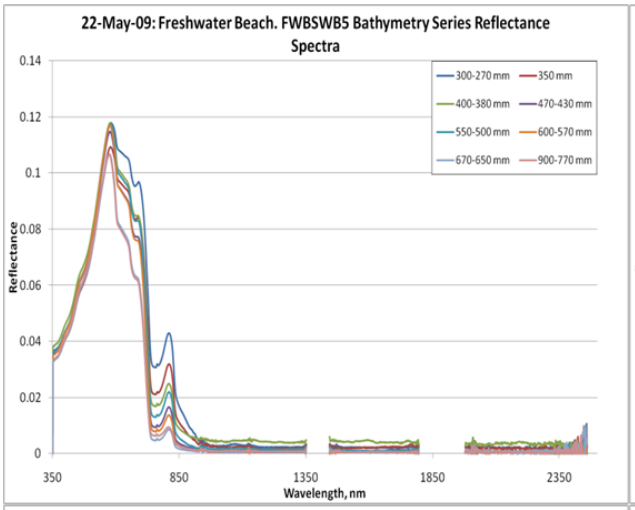

21-May-09: Freshwater Beach. FWBSWB4 Bathymetry Series Reflectance Spectra
60-80 mm
80-110 mm
80-130 mm
85-125 mm
120-110 mm
120-130 mm
130 mm
170- 130 mm
200-130 mm
230-190 mm
235-245 mm
310 mm
330-355 mm
350-300 mm
440-450 mm
450-410 mm
520-510 mm
640-615 mm
660-650 mm
740-690 mm
740-750 mm
805-790 mm
860-830 mm
955-915 mm
965-985 mm
Reflectance
Wavelength, nm

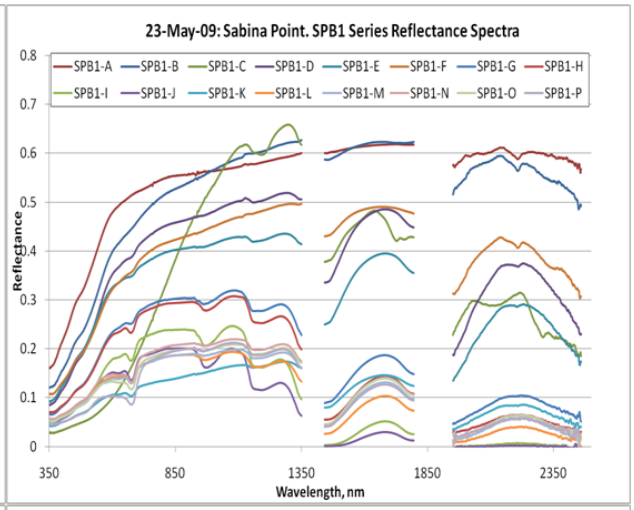

22-May-09: Freshwater Beach. FWB-5 Series Reflectance Spectra
FWB5A
FWB5B
FWB5C
FWB5D
FWB5E
FWB5F
FWB5G
Reflectance
Wavelength, nm

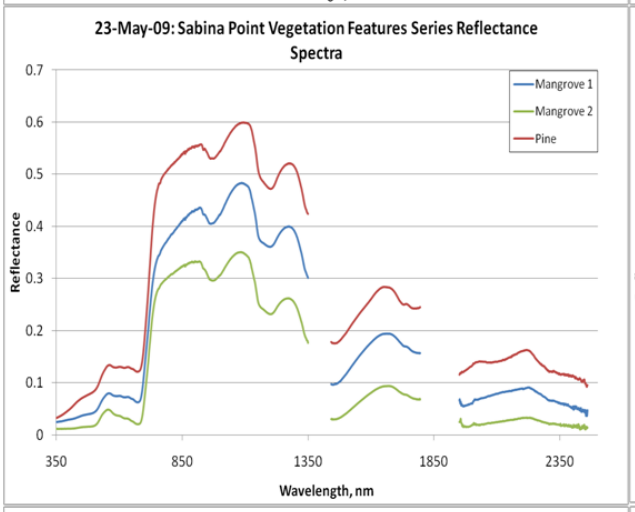

22-May-09: Freshwater Beach. FWA-5 Series Reflectance Spectra
FWA5A
FWA5C
FWA5D
FWA5E
FWA5F
FWA5G
FWA5H
FWA5I
FWA5J
Reflectance
Wavelength, nm

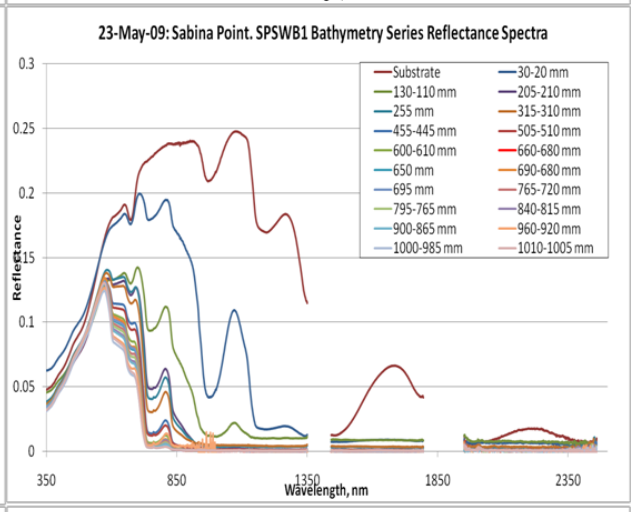

22-May-09: Freshwater Beach. FWB Vegetation Reflectance Spectra
GREENLEAF
Dunegrass
Dunegrass2
Vine
Reflectance
Wavelength, nm

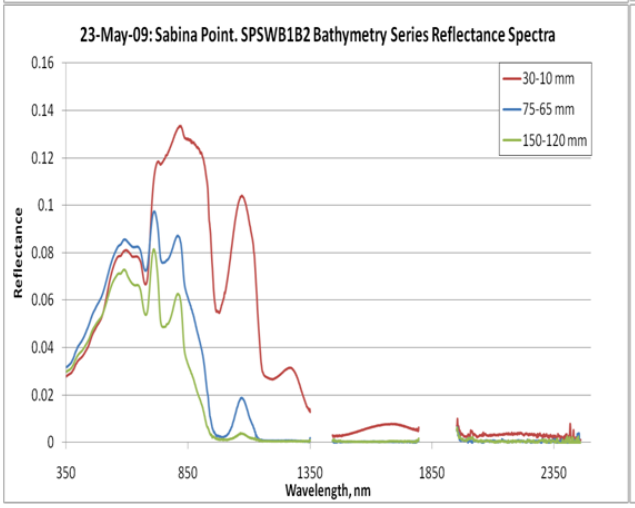

22-May-09: Freshwater Beach.FWBSE Local Feature Series Reflectance Spectra
FWBSE_01
FWBSE_02
FWBSE_03
FWBSE_04
FWBSE_05
Reflectance
Wavelength, nm

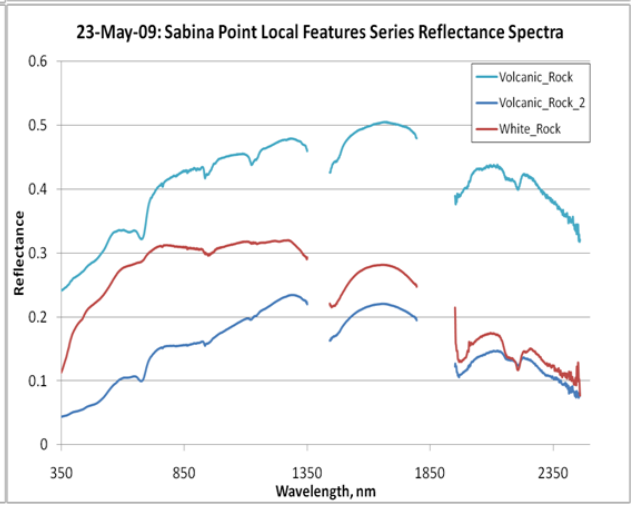

22-May-09: Freshwater Beach. FWBSWB5 Bathymetry Series Reflectance Spectra
300-270 mm
350 mm
400-380 mm
470-430 mm
550-500 mm
600-570 mm
670-650 mm
900-770 mm
Reflectance
Wavelength, nm

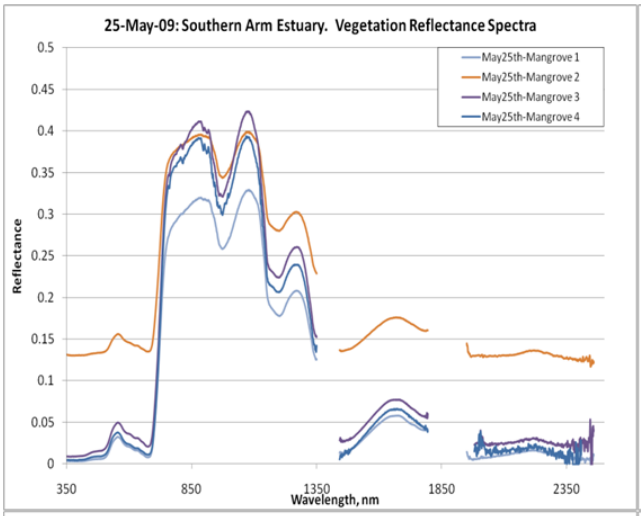

23-May-09: Sabina Point. SPB1 Series Reflectance Spectra
SPB1-A
SPB1-B
SPB1-C
SPB1-D
SPB1-E
SPB1-F
SPB1-G
SPB1-H
SPB1-I
SPB1-J
SPB1-K
SPB1-L
SPB1-M
SPB1-N
SPB1-O
SPB1-P
Reflectance
Wavelength, nm

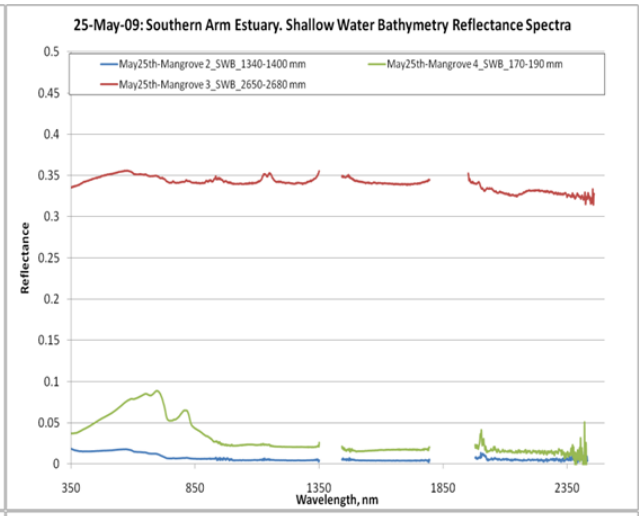

23-May-09: Sabina Point Vegetation Features Series Reflectance Spectra
Mangrove 1
Mangrove 2
Pine
Reflectance
Wavelength, nm

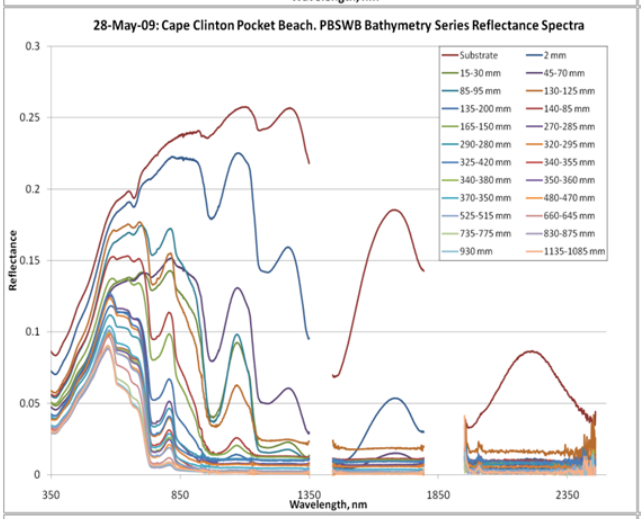

23-May-09: Sabina Point. SPSWB1 Bathymetry Series Reflectance Spectra
Substrate
30-20 mm
130-110 mm
205-210 mm
255 mm
315-310 mm
455-445 mm
505-510 mm
600-610 mm
660-680 mm
650 mm
690-680 mm
695 mm
765-720 mm
795-765 mm
840-815 mm
900-865 mm
960-920 mm
1000-985 mm
1010-1005 mm
Reflectance
Wavelength, nm

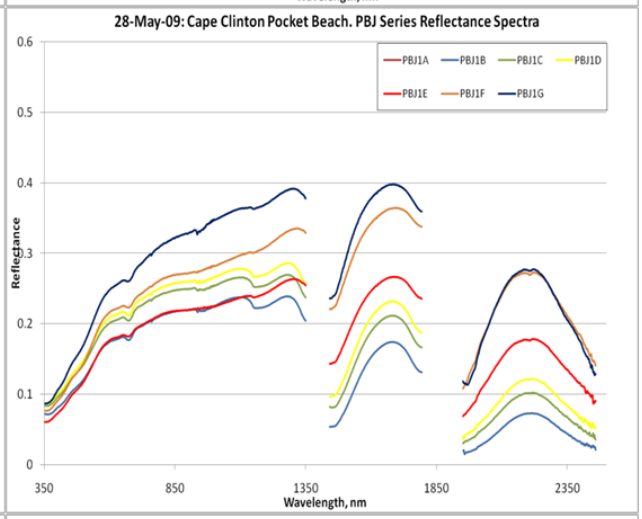

23-May-09: Sabina Point. SPSWB1B2 Bathymetry Series Reflectance Spectra
30-10 mm
75-65 mm
150-120 mm
Reflectance
Wavelength, nm

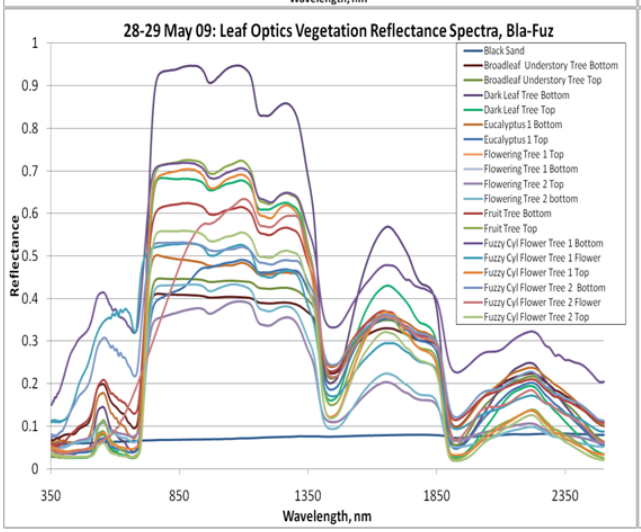

23-May-09: Sabina Point Local Features Series Reflectance Spectra
Volcanic_Rock
Volcanic_Rock_2
White_Rock
Reflectance
Wavelength, nm

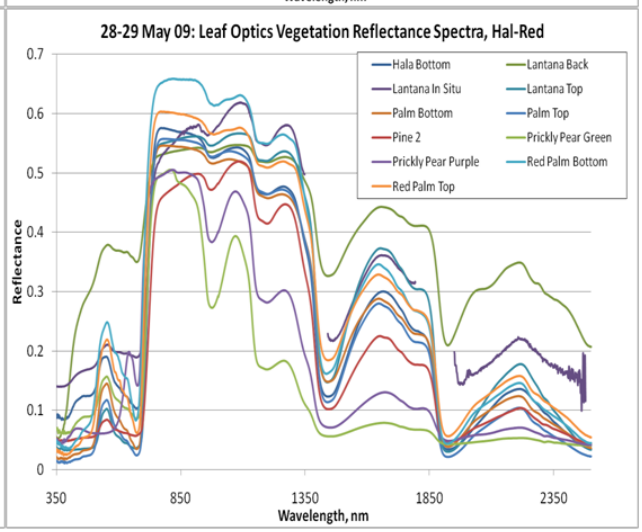

25-May-09: Southern Arm Estuary. Vegetation Reflectance Spectra
May25th-Mangrove 1
May25th-Mangrove 2
May25th-Mangrove 3
May25th-Mangrove 4
Reflectance
Wavelength, nm

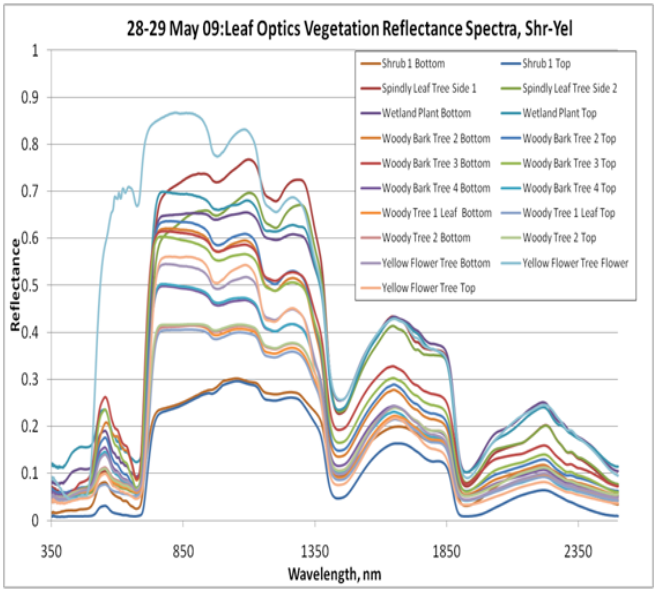

25-May-09: Southern Arm Estuary. Shallow Water Bathymetry Reflectance Spectra
May25th-Mangrove 2_SWB_1340-1400 mm
May25th-Mangrove 4_SWB_170-190 mm
May25th-Mangrove 3_SWB_2650-2680 mm
Reflectance
Wavelength, nm


28-May-09: Cape Clinton Pocket Beach. PBSWB Bathymetry Series Reflectance Spectra
Substrate
2 mm
15-30 mm
45-70 mm
85-95 mm
130-125 mm
135-200 mm
140-85 mm
165-150 mm
270-285 mm
290-280 mm
320-295 mm
325-420 mm
340-355 mm
340-380 mm
350-360 mm
370-350 mm
480-470 mm
525-515 mm
660-645 mm
735-775 mm
830-875 mm
930 mm
1135-1085 mm
Reflectance
Wavelength, nm


28-May-09: Cape Clinton Pocket Beach. PBJ Series Reflectance Spectra
PBJ1A
PBJ1B
PBJ1C
PBJ1D
PBJ1E
PBJ1F
PBJ1G
Reflectance
Wavelength, nm


28-29 May 09: Leaf Optics Vegetation Reflectance Spectra, Bla-Fuz
Black Sand
Broadleaf Understory Tree Bottom
Broadleaf Understory Tree Top
Dark Leaf Tree Bottom
Dark Leaf Tree Top
Eucalyptus 1 Bottom
Eucalyptus 1 Top
Flowering Tree 1 Top
Flowering Tree 1 Bottom
Flowering Tree 2 Top
Flowering Tree 2 bottom
Fruit Tree Bottom
Fruit Tree Top
Fuzzy Cyl Flower Tree 1 Bottom
Fuzzy Cyl Flower Tree 1 Flower
Fuzzy Cyl Flower Tree 1 Top
Fuzzy Cyl Flower Tree 2 Bottom
Fuzzy Cyl Flower Tree 2 Flower
Fuzzy Cyl Flower Tree 2 Top
Reflectance
Wavelength, nm


28-29 May 09: Leaf Optics Vegetation Reflectance Spectra, Hal-Red
Hala Bottom
Lantana Back
Lantana In Situ
Lantana Top
Palm Bottom
Palm Top
Pine 2
Prickly Pear Green
Prickly Pear Purple
Red Palm Bottom
Red Palm Top
Reflectance
Wavelength, nm

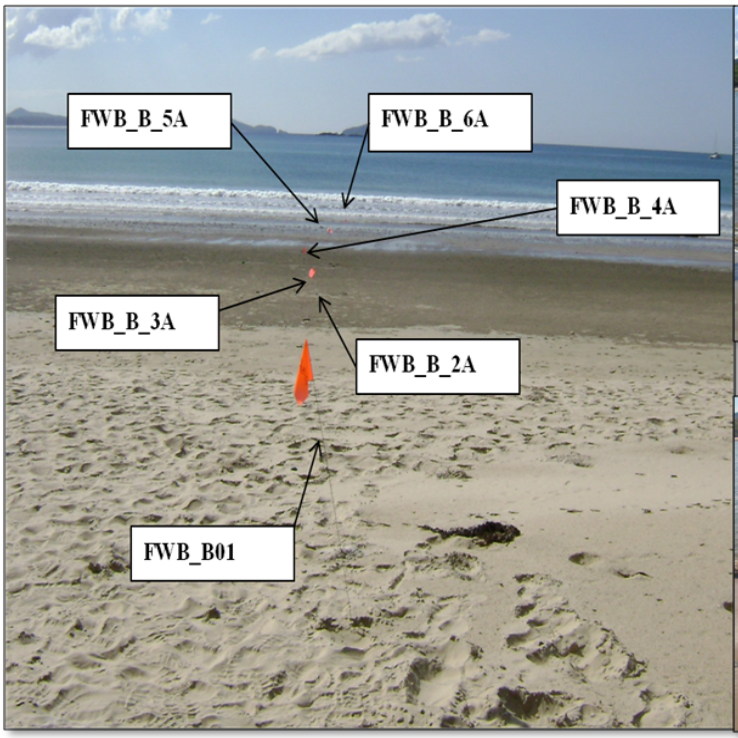

28-29 May 09:Leaf Optics Vegetation Reflectance Spectra, Shr-Yel
Reflectance
Wavelength, nm
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
350
850
1350
1850
2350
Shrub 1 Bottom
Shrub 1 Top
Spindly Leaf Tree Side 1
Spindly Leaf Tree Side 2
Wetland Plant Bottom
Wetland Plant Top
Woody Bark Tree 2 Bottom
Woody Bark Tree 2 Top
Woody Bark Tree 3 Bottom
Woody Bark Tree 3 Top
Woody Bark Tree 4 Bottom
Woody Bark Tree 4 Top
Woody Tree 1 Leaf Bottom
Woody Tree 1 Leaf Top
Woody Tree 2 Bottom
Woody Tree 2 Top
Yellow Flower Tree Bottom
Yellow Flower Tree Flower
Yellow Flower Tree Top

3. Site Photographs

3.1. Freshwater Beach:20 May 2009

FWA-1A FWA-1B FWA-1C

FWA-1D FWA-1E FWA-1F



FWB_B Series

FWB-SB Series

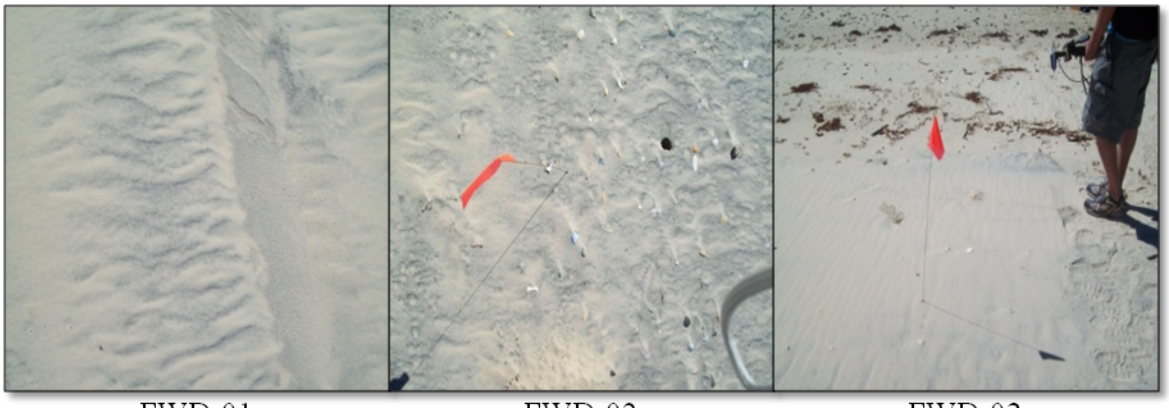
SWBA Series

3.2 Freshwater Beach: 21 May 2009

FWA-3A FWA-3B FWA-3C

FWA-3D FWA-3E FWA-3F

FWA-3G

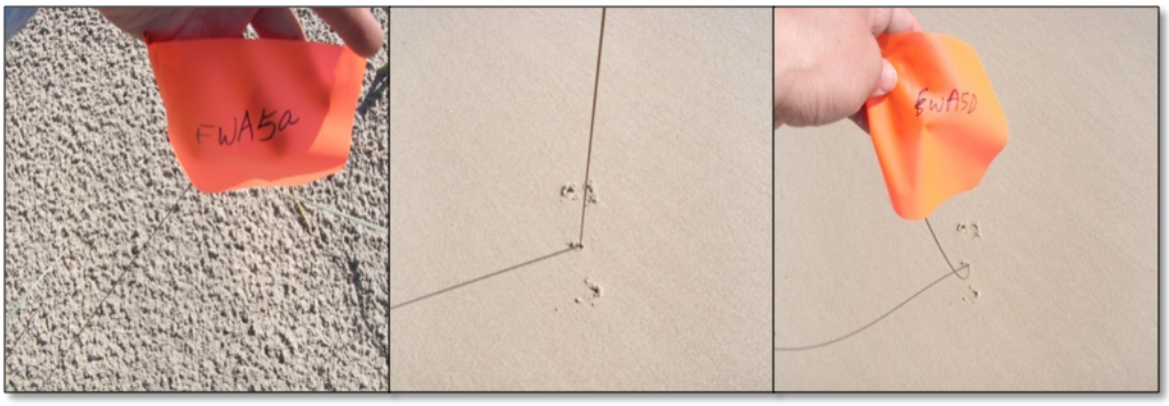


FWD-01 FWD-02 FWD-03

FWD-04 FWD-05 FWD-06

FWBSWB4 Series FWBSWB4 Series

3.3 Freshwater Beach: 22 May 2009

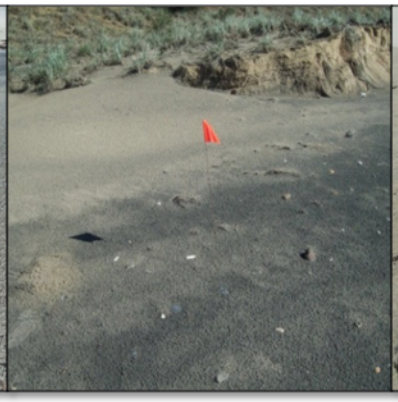


FWA5A FWA5C FWA5D

FWA5E FWA5F FWA5G

FWA5H FWA5I FWA5J

FWB5A



FWB5B

FWB5C

FWB5D

FWB5E

FWB5F

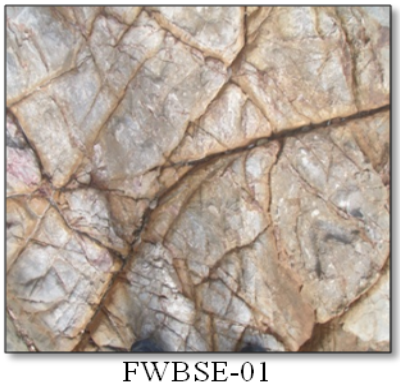
FWB5G

Dune grass 1

Dune grass 2

Greenleaf

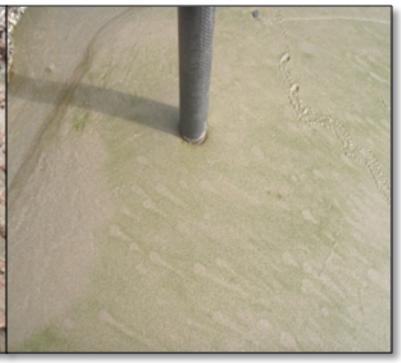
Vine



FWBSE-01

FWBSE-02

FWB-SE-03



FWB-SE-04

FWB-SE-05

FWBSWB5

3.4. Sabina Point: 23 May 2009

SPB1-A SPB1-B SPB1-C

SPB1-D SPB1-E SPB1-F

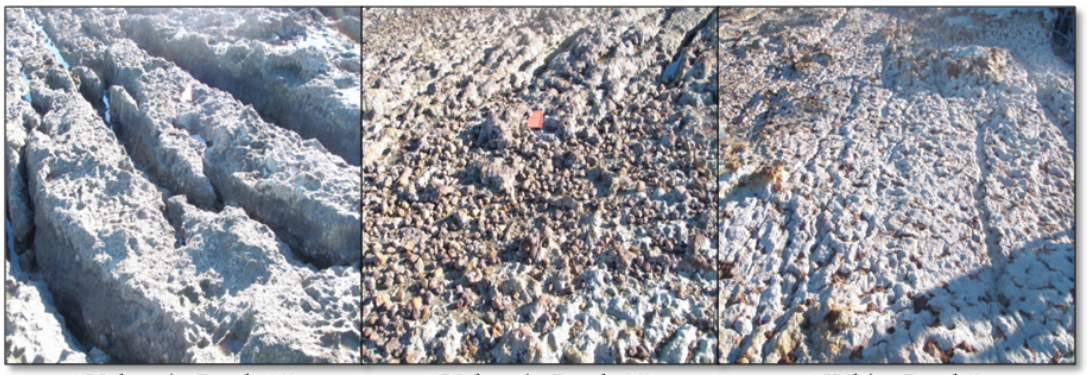
SPB1-G SPB1-H SPB1-I

SPB1-J SPB1-K SPB1-L

SPB1-M SPB1-N SPB1-O

SPB1-P Mangrove 1 Mangrove 2

Pine SPSWB1 SPSWB2



"Volcanic Rock 1" "Volcanic Rock 2" "White Rock"

3.5. Southern Arm Estuary: 25 May 2009

Mangrove 1 Mangrove 2 Mangrove 3

Mangrove 4

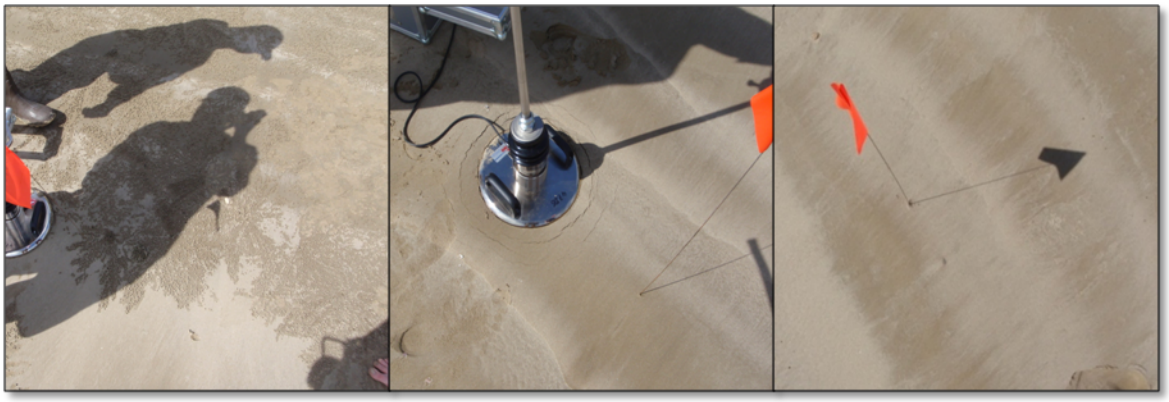
Mangrove 2:
SWB 1340-1400 mm

Mangrove 3 :
SWB 2650-2850 mm

Mangrove 4 :
SWB 170-190 mm

3.6. Cape Clinton Pocket Beach: 28 May 2009

PBJ1A PBJ1B PBJ1C



PBJ1D PBJ1E PBJ1F

PBJ1G PBSWB Series PBSWB Series

3.7. Leaf Optic Spectra: 28-29 May 2009

Black Sand | Broadleaf Understory Tree | Dark Leaf Tree

Dark Leaf Tree Site | Eucalyptus-1 | Eucalyptus-1 Site

Flowering Tree | Flowering Tree Site | Flowering Tree 2

Flowering Tree 2 Site | Fruit Tree | Fruit Tree Site

Fuzzy Cylindrical 1
(*Banksia*)

Fuzzy Cylindrical 1
(*Banksia*)

Fuzzy Cylindrical 2

Fuzzy Cylindrical 2

Hala

Hala Site

Lantana

Lantana Site

Palm 1

Palm 1 Site

Pine-2

Pine 2 Site

Prickly Pear | Prickly Pear Site | Red Palm

Red Palm Site | Shrub 1 | Shrub 1 Site

Spindly Leaf | Spindly Leaf Site | Wetland Plant

Wetland Plant Site | Woody Bark 2 | Woody Bark 2 Site

Woody Bark 3

Woody Bark 3 Site

Woody Bark 4

Woody Bark 4 Site

Woody Tree 1

Woody Tree 1 Site

Woody Tree 2

Woody Tree 2 Site

Yellow Flower 1 (Acacia)

Yellow Flower 1 (Acacia) Site

4. Spectra Comments

4.1. Freshwater Beach: 21-22 May 2009- Calibration Panels

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
White_cal_tarp_01 (Calpanel01)	920	21-May-09	White calibration panel	NRL OLD	B	Single	Good	N/A	Calibration Panel
Black_cal_tarp_01 (Calpanel01)	935	21-May-09	Black calibration panel	NRL OLD	B	Single	Good	N/A	Calibration Panel
White_cal_tarp_02 (Calpanel02)	940	21-May-09	White calibration panel	NRL OLD	B	Single	Good	N/A	Calibration Panel
Black_cal_tarp_02 (Calpanel02)	1015	21-May-09	Black calibration panel	NRL OLD	B	Single	Good	N/A	Calibration Panel
White_cal_tarp_03 (Calpanel03)	1220	21-May-09	White calibration panel	NRL OLD	B	Single	Good	N/A	Calibration Panel
Black_cal_tarp_03 (Calpanel03)	1235	21-May-09	Black calibration panel	NRL OLD	B	Single	Good	N/A	Calibration Panel
White_cal_tarp_04 (Calpanel04)	1240	21-May-09	White calibration panel	NRL OLD	B	Single	Cloud intrusion spectra not taken.	N/A	Calibration Panel
black_cal_tarp_05	925	22-May-09	Black calibration panel	NRL OLD	B	Single	NR	N/A	Calibration Panel
white_cal_tarp_05	857	22-May-09	White calibration panel	NRL OLD	B	Single	NR	N/A	Calibration Panel
black_cal_tarp_06	1020	22-May-09	Black calibration panel	NRL OLD	B	Single	NR	N/A	Calibration Panel
white_cal_tarp_06	935	22-May-09	White calibration panel	NRL OLD	B	Single	NR	N/A	Calibration Panel

4.2. Freshwater Beach: 20 May 2009

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
FWA-1A	1107	20-May-09	Sand	NPS	B	Dual	Mostly sunny	Falling tide	Site
FWA-1B	1110	20-May-09	Medium grained sand	NPS	B	Dual	Mostly sunny	Falling tide	Site
FWA-1C	1120	20-May-09	Hard sand and crab spheroids	NPS	B	Dual	Mostly sunny	Falling tide	Site
FWA-1D	1248	20-May-09	Wet hard sand	NPS	B	Dual	Mostly sunny	Falling tide	Site
FWA-1E	1240	20-May-09	Rocky hard wet sand	NPS	B	Dual	Partly cloudy	Low tide	Site
FWA-1F	1227	20-May-09	Wet sand	NPS	B	Dual	Partly cloudy	Low tide	Site
FWB-B1A	1029	20-May-09	Sandy beach	NRL NEW	A	Dual	Partly cloudy	Falling	Site
FWB-B2A	1231	20-May-09	Beach	NRL NEW	A	Dual	Partly cloudy	Falling, near low water	Site
FWB-B3A	1251	20-May-09	Beach	NRL NEW	A	Dual	Partly cloudy	Low water	Site
FWB-B4A	1259	20-May-09	Beach	NRL NEW	A	Dual	Partly cloudy	Low water	Site
FWB-B5A	1302	20-May-09	Beach	NRL NEW	A	Dual	Partly cloudy	Low water	Site
FWB-B6A	1308	20-May-09	Beach	NRL NEW	A	Dual	Cloudy	Not recorded	Site

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
FWB-SB1	1439	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	Substrate	SW Bathymetry
FWB-SB2	1443	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	Substrate	SW Bathymetry
FWB-SB3	1456	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	200-240 mm	SW Bathymetry
FWB-SB4	1502	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	200-220 mm	SW Bathymetry
FWB-SB4	1507	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	250-265 mm	SW Bathymetry
FWB-SB5	1515	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	320-325 mm	SW Bathymetry
FWB-SB5	1521	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	330-340 mm	SW Bathymetry
FWB-SB5	1530	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	460-500 mm	SW Bathymetry
FWB-SB5	1535	20-May-09	Sandy/rocky bottom	NRL NEW	A	Dual	Partly cloudy	550-600 mm	SW Bathymetry
SWBA-01	1446	20-May-09	Sandy/rocky bottom	NPS	B	Dual	Partly cloudy	Substrate	SW Bathymetry
SWBA-02	1453	20-May-09	Sandy/rocky bottom	NPS	B	Dual	Partly cloudy	0-40 mm	SW Bathymetry
SWBA-03	1500	20-May-09	Sandy/rocky bottom	NPS	B	Dual	Partly cloudy	70-300 mm	SW Bathymetry
SWBA-03	1503	20-May-09	Sandy/rocky bottom	NPS	B	Dual	Partly cloudy	100-300 mm	SW Bathymetry
SWBA-04	1506	20-May-09	Sandy/rocky bottom	NPS	B	Dual	Cloudy	200-420 mm	SW Bathymetry
SWBA-04	1508	20-May-09	Sandy/rocky bottom	NPS	B	Dual	Partly cloudy	350-540 mm	SW Bathymetry

4.3. Freshwater Beach: 21 May 2009

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
FWA3A	1000	21-May-09	Near foredune ridge, sand.	NOAA	D	Single	Clear	Falling	Site
FWA3B	1010	21-May-09	Not recorded	NOAA	D	Single	Clear	Falling	Site
FWA3C	1029	21-May-09	Sand Spheroids present.	NOAA	D	Single	Clear	Falling	Site
FWA3D	1040	21-May-09	Shell/pebble linear beach feature	NOAA	D	Single	Clear	Falling	Site
FWA3E	1143	21-May-09	Near remnant water muddy surface	NOAA	D	Single	Clear	Falling	Site
FWA3F	1157	21-May-09	Sand	NOAA	D	Single	Clear	Low tide	Site
FWA3G	1206	21-May-09	Wet sand above beach swash, some beach scum.	NOAA	D	Single	Clear	Low tide	Site
FWD-01	1006	21-May-09	Beach	NPS	E	Single	Clear and sunny		Site
FWD-02	1018	21-May-09	Beach	NPS	E	Single	Clear and sunny		Site
FWD-03	1100	21-May-09	Beach, rocks and shells	NPS	E	Single	Clear and sunny		Site
FWD-04	1110	21-May-09	Beach, kelp, rocks and shells	NPS	E	Single	Clear and sunny		Site
FWD-05	1141	21-May-09	Moist beach	NPS	E	Single	Clear and sunny		Site
FWD-06	1200	21-May-09	Very little rocks	NPS	E	Single	Clear and sunny		Site

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
FWBSWB_4	1037	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	965-985 mm	SW Bathymetry
FWBSWB_4	1044	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	955-915 mm	SW Bathymetry
FWBSWB_4	1049	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	860-830 mm	SW Bathymetry
FWBSWB_4	1055	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	805-790 mm	SW Bathymetry
FWBSWB_4	1100	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	740-750 mm	SW Bathymetry
FWBSWB_4	1104	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	740-690 mm	SW Bathymetry
FWBSWB_4	1110	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	660-650 mm	SW Bathymetry
FWBSWB_4	1117	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	640-615 mm	SW Bathymetry
FWBSWB_4	1124	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	520-510 mm	SW Bathymetry
FWBSWB_4	1129	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	440-450 mm	SW Bathymetry
FWBSWB_4	1134	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	450-410 mm	SW Bathymetry

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
FWBSWB_4	1140	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	330-355 mm	SW Bathymetry
FWBSWB_4	1148	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	350-300 mm	SW Bathymetry
FWBSWB_4	1152	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	310 mm	SW Bathymetry
FWBSWB_4	1158	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clear and sunny	235-245 mm	SW Bathymetry
FWBSWB_4a	1205	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	230-190 mm	SW Bathymetry
FWBSWB_4a	1210	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	200-130 mm	SW Bathymetry
FWBSWB_4a	1216	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	120-130 mm	SW Bathymetry
FWBSWB_4a	1221	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	80-110 mm	SW Bathymetry
FWBSWB_4a	1230	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	130 mm	SW Bathymetry
FWBSWB_4a	1234	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	120-110 mm	SW Bathymetry
FWBSWB_4a	1239	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	85-125 mm	SW Bathymetry
FWBSWB_4a	1244	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	80-130 mm	SW Bathymetry
FWBSWB_4a	1308	21-May-09	Beach near rocks on SE section of FWB	NRL NEW		Single	Clouding up	60-80 mm	SW Bathymetry

4.4. Freshwater Beach: 22 May 2009

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
FWA5A	914	22-May-09	Sand At Southern Tip of Two Rocks	NOAA	C	Single	Partly Cloudy	High Tide	Site
FWA5C	936	22-May-09	Below Dune, Dark Rippled Sand.	NOAA	C	Single	Clear	High Tide	Site
FWA5D	942	22-May-09		NOAA	C	Single	Clear	Falling	Site
FWA5E	948	22-May-09		NOAA	C	Single	Clear	Falling	Site
FWA5F	958	22-May-09		NOAA	C	Single	Clear	Falling	Site
FWA5G	1004	22-May-09		NOAA	C	Single	High Cirrus Clouds	Falling	Site
FWA5H	1015	22-May-09		NOAA	C	Single	Thick Cirrus Clouds	Falling	Site
FWA5I	1134	22-May-09	Foredune Ridge/Grass Shrubs	NOAA	C	Single	Cirrus Clouds		Site
FWA5J	1157	22-May-09	2nd level of foredune ridge	NOAA	C	Single	Partly Cloudy		Site
FWB5A	917	22-May-09	Wet sand with stipples.	NPS	E	Single	Scattered clouds. Slight breeze blue sky with high thin cirrus clouds near sun. Cumulus clouds on horizon. HyVista plane observed.		Site
FWB5B	925	22-May-09	Dark, wet stippled sand with sparse shells.	NPS	E	Single	Clouds on horizon		Site
FWB5C	930	22-May-09	Sand with stones shells and seaweed	NPS	E	Single	Not recorded		Site
FWB5D	1029	22-May-09	Sandy Beach	NPS	E	Single	Cirrus		Site
FWB5E	1046	22-May-09	Damp smooth sand with small sparse pebbles.	NPS	E	Single	High Clouds		Site
FWB5F	1058	22-May-09	Damp sand with dense rock coverage.	NPS	E	Single	High Clouds		Site
FWB5G	1110	22-May-09	Damp sand with sparse pebble and shell coverage.	NPS	E	Single	High Clouds		Site

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
FWBSWB5	920	22-May-09	beach near rocks on SE section of FWB	NRL NEW	D	Single	Clear and sunny with increasing clouds later in day	900-770 mm	SW Bathymetry
FWBSWB5	927	22-May-09	beach near rocks on SE section of FWB	NRL NEW	D	Single	Clear and sunny with increasing clouds later in day	670-650 mm	SW Bathymetry
FWBSWB5	932	22-May-09	beach near rocks on SE section of FWB	NRL NEW	D	Single	Clear and sunny with increasing clouds later in day	600-570 mm	SW Bathymetry
FWBSWB5	937	22-May-09	beach near rocks on SE section of FWB	NRL NEW	D	Single	Clear and sunny with increasing clouds later in day	550-500 mm	SW Bathymetry
FWBSWB5	942	22-May-09	beach near rocks on SE section of FWB	NRL NEW	D	Single	Clear and sunny with increasing clouds later in day	470-430 mm	SW Bathymetry
FWBSWB5	946	22-May-09	beach near rocks on SE section of FWB	NRL NEW	D	Single	Clear and sunny with increasing clouds later in day	380-400 mm	SW Bathymetry
FWBSWB5	950	22-May-09	beach near rocks on SE section of FWB	NRL NEW	D	Single	Clear and sunny with increasing clouds later in day	350 mm	SW Bathymetry
FWBSWB5	955	22-May-09	beach near rocks on SE section of FWB	NRL NEW	D	Single	Clear and sunny with increasing clouds later in day	300-270 mm	SW Bathymetry

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
GREENLEAF	1146	22-May-09	Green leaf plant	NOAA	C	Single			Vegetative feature
Dunegrass	1131	22-May-09	Plant	NOAA	C	Single			Vegetative feature
Dunegrass2	1144	22-May-09	Sand with grass	NOAA	C	Single			Vegetative feature
Vine	922	22-May-09	Foredune ridge	NOAA	C	Single			Vegetative feature
FWBSE_01	1113	22-May-09	Light gray and brown stratified rock.	NRL NEW	A	Dual	Stratus	Not recorded	Local feature (rock)
FWBSE_02	1148	22-May-09	Wet sand average measurement	NRL NEW	A	Dual	Stratus	Not recorded	Local feature (rock)
FWBSE_03	1249	22-May-09	Red rocks and muddy sand.	NRL NEW	A	Dual	Stratus partly cloudy	Falling to low tide	Local feature (rock)
FWBSE_04	1257	22-May-09	Green algae spots on sand.	NRL NEW	A	Dual	Stratus	Falling to low tide	Local feature (rock)
FWBSE_05	1307	22-May-09	Whitish gray rocks	NRL NEW	A	Dual	Stratus	Near low tide	Local feature (rock)

4.5. Sabina Point: 23 May 2009

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
SPB1-A	959	23-May-09	Dunes	NRL OLD	E	Single	Clear	High Tide	Site
SPB1-B	1012	23-May-09	Dried leaves	NRL OLD	E	Single	Clear	High Tide	Site
SPB1-C	1021	23-May-09	Leaves and sticks	NRL OLD	E	Single	Clear	Falling	Site
SPB1-D	1028	23-May-09	Small shells and rocks on beach	NRL OLD	E	Single	Clear	Falling	Site
SPB1-E	1035	23-May-09	Sand	NRL OLD	E	Single	Clear	Falling	Site
SPB1-F	1044	23-May-09	Beach	NRL OLD	E	Single	Clear	Falling	Site
SPB1-G	1116	23-May-09	Damp sand	NRL OLD	E	Single	Clear	Falling	Site
SPB1-H	1133	23-May-09	Wet sand close to water's edge	NRL OLD	E	Single	Clear	Falling	Site
SPB1-I	1302	23-May-09	Beach	NRL OLD	E	Single	Clear	Falling	Site
SPB1-J	1315	23-May-09	Beach	NRL OLD	E	Single	Clear	Falling	Site
SPB1-K	1323	23-May-09	Beach with rocks	NRL OLD	E	Single	Clear	Falling	Site
SPB1-L	1340	23-May-09	Beach	NRL OLD	E	Single	Clear	Falling	Site
SPB1-M	1403	23-May-09	Moderately deep sinking sad/mud.	NRL OLD	E	Single	Clear	Near low tide	Site
SPB1-N	1457	23-May-09	Sparse sea grass in wet sand.	NRL OLD	E	Single	Clear	Low tide	Site
SPB1-O	1507	23-May-09	Sea grass on wet sand	NRL OLD	E	Single	Clear	Low tide	Site
SPB1-P	1518	23-May-09	Denser sea grass	NRL OLD	E	Single	Clear	Low tide	Site

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
SPSWB1	1007	23-May-09	inundated sand	NRL NEW	D	Single	Clear	1010-1005 mm	SW Bathymetry
SPSWB1	1024	23-May-09	inundated sand	NRL NEW	D	Single	Clear	1000-985 mm	SW Bathymetry
SPSWB1	1028	23-May-09	inundated sand	NRL NEW	D	Single	Clear	960-920 mm	SW Bathymetry
SPSWB1	1034	23-May-09	inundated sand	NRL NEW	D	Single	Clear	900-865 mm	SW Bathymetry
SPSWB1	1037	23-May-09	inundated sand	NRL NEW	D	Single	Clear	840-815 mm	SW Bathymetry
SPSWB1	1040	23-May-09	inundated sand	NRL NEW	D	Single	Clear	795-765 mm	SW Bathymetry
SPSWB1	1046	23-May-09	inundated sand	NRL NEW	D	Single	Clear	765-720 mm	SW Bathymetry
SPSWB1	1050	23-May-09	inundated sand	NRL NEW	D	Single	Clear	690-680 mm	SW Bathymetry
SPSWB1	1053	23-May-09	inundated sand	NRL NEW	D	Single	Clear	695-695 mm	SW Bathymetry
SPSWB1	1057	23-May-09	inundated sand	NRL NEW	D	Single	Clear	680-680 mm	SW Bathymetry
SPSWB1	1101	23-May-09	inundated sand	NRL NEW	D	Single	Clear	660-680 mm	SW Bathymetry
SPSWB1	1107	23-May-09	inundated sand	NRL NEW	D	Single	Clear	600-610 mm	SW Bathymetry
SPSWB1	1116	23-May-09	inundated sand	NRL NEW	D	Single	Clear	505-510 mm	SW Bathymetry
SPSWB1	1121	23-May-09	inundated sand	NRL NEW	D	Single	Clear	455-445 mm	SW Bathymetry
SPSWB1	1130	23-May-09	inundated sand	NRL NEW	D	Single	Clear	315-310 mm	SW Bathymetry
SPSWB1b	1135	23-May-09	inundated sand	NRL NEW	D	Single	Clear	255-255 mm	SW Bathymetry
SPSWB1b	1139	23-May-09	inundated sand	NRL NEW	D	Single	Clear	205-210 mm	SW Bathymetry
SPSWB1b	1145	23-May-09	inundated sand	NRL NEW	D	Single	Clear	130-110 mm	SW Bathymetry
SPSWB1b	1149	23-May-09	inundated sand	NRL NEW	D	Single	Clear	30-10 mm	SW Bathymetry
SPSWB1b	1152	23-May-09	inundated sand	NRL NEW	D	Single	Clear	Dry	SW Bathymetry
SPSWB1b2	1329	23-May-09	Peat/Seagrass	NRL NEW	D	Single	Clear	150-120 mm	SW Bathymetry
SPSWB1b2	1334	23-May-09	Peat/Seagrass	NRL NEW	D	Single	Clear	75-65 mm	SW Bathymetry
SPSWB1b2	1338	23-May-09	Peat/Seagrass	NRL NEW	D	Single	Clear	30-10 mm	SW Bathymetry

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
"Volcanic-Rock"	1510	23-May-09	Rocky outcrop	NRL NEW	D	Single	Clear	N/A	Local feature (rock)
"Volcanic Rock 2"	1521	23-May-09	Red stone	NRL NEW	D	Single	Clear	N/A	Local feature (rock)
"White_Rock"	1545	23-May-09	White rock	NRL NEW	D	Single	Clear	N/A	Local feature (rock)
Mangrove1 (sp_mangr)	1442	23-May-09	Juvenile mangroves in rock area	NRL NEW	D	Single	Clear	N/A	Vegetative feature
Mangrove2 (sp_mang2)	1500	23-May-09	Juvenile mangroves in rock area	NRL NEW	D	Single	Clear	N/A	Vegetative feature
Pine (sp_pine)	1425	23-May-09	Pine trees in sand by entrance to Sabina Point Beach	NRL NEW	D	Single	Clear	N/A	Vegetative feature

4.6. Southern Arm Estuary: 25 May 2009

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
Mangrove2_SWB	1028	25-May-09	Mangrove in estuary area	NRL NEW	B	Dual	Mostly cloudy, variable	1340-1400 mm	SW Bathymetry
Mangrove 3 SWB	1115	25-May-09	Mangrove in estuary area	NRL NEW	B	Dual	Mostly cloudy	2650-2680 mm	SW Bathymetry
Mangrove4-SWB	1212	25-May-09	Mangrove in estuary area	NRL NEW	B	Dual	Thin clouds	170-190 mm	SW Bathymetry
Mangrove1	944	25-May-09	Mangrove in estuary area	NRL NEW	B	Dual	Cloudy	Tide falling	Vegetative feature
Mangrove2	1029	25-May-09	Mangrove in estuary area	NRL NEW	B	Dual	Mostly cloudy	Tide falling	Vegetative feature
Mangrove3	1112	25-May-09	Mangrove in estuary area	NRL NEW	E	Dual	Cloudy	Tide falling	Vegetative feature
Mangrove4	1212	25-May-09	Mangrove in estuary area	NRL NEW	E	Dual	Cloudy	Tide falling	Vegetative feature

4.7. Cape Clinton Pocket Beach: 28 May 2009

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
PBJ1A	1055	28-May-09	Beach	NPS	E	Dual	Variable Clouds		Site
PBJ1B	1114	28-May-09	Beach	NPS	E	Dual			Site
PBJ1C	1132	28-May-09	Beach	NPS	E	Dual			Site
PBJ1D	1201	28-May-09	Beach	NPS	E	Dual			Site
PBJ1E	1217	28-May-09	Beach	NPS	E	Dual			Site
PBJ1F	1234	28-May-09	Beach	NPS	E	Dual			Site
PBJ1G	1248	28-May-09	Beach	NPS	E	Dual			Site

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
PBSWB_5_28	1100	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	dry	SW Bathymetry
PBSWB_5_28	1101	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	dry-dry	SW Bathymetry
PBSWB_5_28	1105	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	2- 2 mm	SW Bathymetry
PBSWB_5_28	1113	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	15-30 mm	SW Bathymetry
PBSWB_5_28	1119	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	45-70 mm	SW Bathymetry
PBSWB_5_28	1124	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	85-45 mm	SW Bathymetry
PBSWB_5_28	1131	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	140-85 mm	SW Bathymetry
PBSWB_5_28	1135	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	130-125 mm	SW Bathymetry
PBSWB_5_28	1142	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	165-150 mm	SW Bathymetry
PBSWB_5_28	1150	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	135-200 mm	SW Bathymetry
PBSWB_5_28	1157	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	270-285 mm	SW Bathymetry
PBSWB_5_28	1204	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	290-280 mm	SW Bathymetry
PBSWB_5_28	1210	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	320-295 mm	SW Bathymetry
PBSWB_5_28	1215	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	340-355 mm	SW Bathymetry
PBSWB_5_28	1220	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	325-420 mm	SW Bathymetry
PBSWB_5_28	1225	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	370-350 mm	SW Bathymetry
PBSWB_5_28	1232	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	350-360 mm	SW Bathymetry
PBSWB_5_28B	1242	28-May-09	inundated sand position 1	NRL NEW	D	Dual	Mostly cloudy, variable	340-380 mm	SW Bathymetry

Site Name	Time	Date	Vegetation/Land Cover Type	ASD	ASD Plaque	Spectrometer Mode	Atmospheric Condition	Water Level	Collection Type
PBSWB_5_28B	1253	28-May-09	inundated sand position 2	NRL NEW	D	Dual	Mostly cloudy, variable	480-470 mm	SW Bathymetry
PBSWB_5_28B	1307	28-May-09	inundated sand position 3	NRL NEW	D	Dual	Partly Cloudy	525-515 mm	SW Bathymetry
PBSWB_5_28B	1312	28-May-09	inundated sand position 4	NRL NEW	D	Dual	Partly Cloudy	660-645 mm	SW Bathymetry
PBSWB_5_28B	1320	28-May-09	inundated sand position 5	NRL NEW	D	Dual	Partly Cloudy	735-775 mm	SW Bathymetry
PBSWB_5_28B	1327	28-May-09	inundated sand position 6	NRL NEW	D	Dual	Partly Cloudy	830-875 mm	SW Bathymetry
PBSWB_5_28B	1335	28-May-09	inundated sand position 7	NRL NEW	D	Dual	Partly Cloudy	930-930 mm	SW Bathymetry
PBSWB_5_28B	1347	28-May-09	inundated sand position 8	NRL NEW	D	Dual	Partly Cloudy	1135-1085 mm	SW Bathymetry

4.8. Leaf Optics: 28-29 May 2009

Description	Date	Time	Coordinates of Collected Sample	ASD	ASD Plaque	Spectrometer Mode	Leaf Optics (LO) Sample Number	Additional Comments
Black Sand	29-May-09	1448		NRL NEW	D	Leaf optics	NR	Contact probe directly on sand. Sample found by J. Sellars.
Broadleaf Understory Tree Bottom	28-May-09		22.653095 S,150.722687 E	NRL NEW	C	Leaf optics	4	Broadleaf understory tree. Height 18 ft.
Broadleaf Understory Tree Top	28-May-09		22.653095 S,150.722687 E	NRL NEW	C	Leaf optics	4	Broadleaf understory tree. Height 18 ft.
Dark Leaf Tree Bottom	29-May-09	1314	22.652147 S, 150.785082 E	NRL NEW	D	Leaf optics	18	Height about 30 ft. On FWB rd 500m from beach.
Dark Leaf Tree Top	29-May-09	1323	22.652147 S, 150.785082 E	NRL NEW	D	Leaf optics	18	Height about 30 ft. On FWB rd 500m from beach.
Eucalyptus 1 Top	29-May-09	1217	22.650632 S, 150.78878 E	NRL NEW	D	Leaf optics	10	
Eucalyptus 1 Bottom	29-May-09	1222	22.650632 S, 150.78878 E	NRL NEW	D	Leaf optics	10	
Flowering Tree 1 Top	28-May-09	1746	22.658016 S, 150.714644 E	NRL NEW	C	Leaf optics	6	Height about 20 ft. On FWB road.
Flowering Tree 1 Bottom	28-May-09	1747	22.658016 S, 150.714644 E	NRL NEW	C	Leaf optics	6	Height about 20 ft. On FWB road.

Description	Date	Time	Coordinates of Collected Sample	ASD	ASD Plaque	Spectrometer Mode	Leaf Optics (LO) Sample Number	Additional Comments
Flowering Tree 2 Top	28-May-09	1752	22.657988 S, 150.714668 E	NRL NEW	C	Leaf optics	7	Mislabeled originally. Has pods, directly behind juvenile version of LO #6 but a different species.
Flowering Tree 2 Bottom	28-May-09	1755	22.657988 S, 150.714668 E	NRL NEW	C	Leaf optics	7	Mislabeled originally. Has pods, directly behind juvenile version of LO #6 but a different species.
Fruit Tree Bottom	29-May-09	1432	22.648915 S, 150.791918 E	NRL NEW	D	Leaf optics	16	FWB rocky area east of beach access pt. Orange/yellow fruit with narrow trunk.
Fruit Tree Top	29-May-09	1430	22.648915 S, 150.791918 E	NRL NEW	D	Leaf optics	16	FWB rocky area east of beach access pt. Orange/yellow fruit with narrow trunk.
Fuzzy Cyl Flower Tree 1 Bottom	29-May-09	1332	22.65433 S, 150.778665 E	NRL NEW	D	Leaf optics	21	Banksia genus.
Fuzzy Cyl Flower Tree 1 Flower	29-May-09	1338	22.65433 S, 150.778665 E	NRL NEW	D	Leaf optics	21	Banksia genus.
Fuzzy Cyl Flower Tree 1 Top	29-May-09	1335	22.65433 S, 150.778665 E	NRL NEW	D	Leaf optics	21	Banksia genus.
Fuzzy Cyl Flower Tree 2 Bottom	29-May-09	1229	22.65446 S, 150.777409 E	NRL NEW	D	Leaf optics	22	
Fuzzy Cyl Flower Tree 2 Flower	29-May-09	1238	22.65446 S, 150.777409 E	NRL NEW	D	Leaf optics	22	

Description	Date	Time	Coordinates of Collected Sample	ASD	ASD Plaque	Spectrometer Mode	Leaf Optics (LO) Sample Number	Additional Comments
Fuzzy Cyl Flower Tree 2 Top	29-May-09	1233	22.65446 S, 150.777409 E	NRL NEW	D	Leaf optics	22	
Hala Bottom	29-May-09	1122	22.640578 S, 150.759716 E	NRL NEW	D	Leaf optics	23	Razor sharp leaves, large fruit approximately pineapple sized. Growing across river near FWB road split.
Hala Top	29-May-09	1118	22.640578 S, 150.759716 E	NRL NEW	D	Leaf optics	23	Razor sharp leaves, large fruit approximately pineapple sized. Growing across river near FWB road split.
Lantana Back	28-May-09	1714	22.739656 S, 150.664731 E	NRL NEW	C	Leaf optics	1	Height=176cm, Near Sam Hill.
Lantana In Situ (lantana canopy)	29-May-09	1000	22.739656 S, 150.66471 E	NRL NEW	D	Single	N/A	Spectra taken at location on 5/29/09
Lantana Top	28-May-09	1711	22.739656 S, 150.664731 E	NRL NEW	C	Leaf optics	1	Height=176cm, Near Sam Hill.
Palm tree (Coconut)	27-May-09	1329	22.650218 S, 150.790923 E	N/A	N/A	N/A	17	Sample not taken. Position taken for ground control.
Palm tree (Coconut)	27-May-09	1329	22.650218 S , 150.790923 E	N/A	N/A	N/A	17	Sample not taken. Position taken for ground control.

Description	Date	Time	Coordinates of Collected Sample	ASD	ASD Plaque	Spectrometer Mode	Leaf Optics (LO) Sample Number	Additional Comments
Palm-1 Top	28-May-09	1727	22.653095 S, 150.722658 E	NRL NEW	C	Leaf optics	2	Palm trees located on FWB rd. Height approx. 22ft.
Palm-1 Bottom	28-May-09	1728	22.653095 S, 150.722658 E	NRL NEW	C	Leaf optics	2	Palm trees located on FWB rd. Height approx. 22ft.
Pine 2	29-May-09	924	22.657877 S, 150.714878 E	NRL NEW	D	Leaf optics	9	Casuarina genus. Species located on FWB road.
Prickly Pear Green	29-May-09	1442	22.648957 S, 150.791879 E	NRL NEW	D	Leaf optics	15	Found in understory 5/27. Direct contact of probe on plant.
Prickly Pear Purple	29-May-09	1444	22.648957 S, 150.791879 E	NRL NEW	D	Leaf optics	15	Found in understory 5/27. Direct contact of probe on plant.
Red Palm Bottom (rtcrpalm)	29-May-09	1400	22.640663 S, 150.759616 E	NRL NEW	D	Leaf optics	24	Plant height 28ft. On FWB Rd near split around ravine/river.
Red Palm Top(rtcrpalm)	29-May-09	1359	22.640663 S, 150.759616 E	NRL NEW	D	Leaf optics	24	Plant height 28ft. On FWB Rd near split around ravine/river.
Shrub 1 Bottom	28-May-09	1054	FWB Road	NRL NEW	C	Leaf optics	5	Height approx 5ft. Location of sample at FWB.
Shrub 1 Top	28-May-09	1050	FWB Road	NRL NEW	C	Leaf optics	5	Height approx 5ft. Location of sample at FWB.
Spindly Leaf Tree Side 1	29-May-09	1418	22.652762 S, 150.781305 E	NRL NEW	D	Leaf optics	20	FWB road. Height= 17ft.

Description	Date	Time	Coordinates of Collected Sample	ASD	ASD Plaque	Spectrometer Mode	Leaf Optics (LO) Sample Number	Additional Comments
Spindly Leaf Tree Side 2	29-May-09	1421	22.652762 S, 150.781305 E	NRL NEW	D	Leaf optics	20	FWB road. Height= 17ft.
Wetland Plant Bottom (blwp1)	29-May-09	1250	22.652069 S, 150.784997 E	NRL NEW	D	Leaf optics	19	FWB rd 500m from beach. Height=1.51m.
Wetland Plant Top (blwp1)	29-May-09	1253	22.652069 S, 150.784997 E	NRL NEW	D	Leaf optics	19	FWB rd 500m from beach. Height=1.51m
Woody Bark Tree 2 Bottom	29-May-09	1202	22.650612 S, 150.788724 E	NRL NEW	D	Leaf optics	11	May be another type of eucalyptus. Spatially close to LO #10.
Woody Bark Tree 2 Top	29-May-09	1205	22.650612 S, 150.788724 E	NRL NEW	D	Leaf optics	11	May be another type of eucalyptus. Spatially close to LO #10.
Woody Bark Tree 3 Bottom	29-May-09	1410	22.650461 S, 150.7892 E	NRL NEW	D	Leaf optics	12	Similar to LO # 11. Species isolated and growing in sand. Some type of eucalyptus.
Woody Bark Tree 3 Top	29-May-09	1407	22.650461 S, 150.7892 E	NRL NEW	D	Leaf optics	12	Similar to LO # 11. Species isolated and growing in sand. Some type of eucalyptus.
Woody Bark Tree 4 Bottom	29-May-09	1353	22.650427 S, 150.78964 E	NRL NEW	D	Leaf optics	13	Possibly eucalyptus but could be acacia. White peeling bark.

Description	Date	Time	Coordinates of Collected Sample	ASD	ASD Plaque	Spectrometer Mode	Leaf Optics (LO) Sample Number	Additional Comments
Woody Bark Tree 4 Top	29-May-09	1351	22.650427 S, 150.78964 E	NRL NEW	D	Leaf optics	13	Possibly eucalyptus but could be acacia. White peeling bark
Woody Tree 1 Leaf Bottom	28-May-09	1735	22.652979 S, 150.722616 E	NRL NEW	C	Leaf optics	3	Understory tree on FWB rd. Height approx 13ft.
Woody Tree 1 Leaf Top	28-May-09	1734	22.652979 S, 150.722616 E	NRL NEW	C	Leaf optics	3	Understory tree on FWB rd. Height approx 13ft.
Woody Tree 2 Bottom	28-May-09	1800	22.657968 S, 150.714688 E	NRL NEW	C	Leaf optics	8	Same species as LO #7 but more mature.
Woody Tree 2 Top	28-May-09	1759	22.657968 S, 150.714688 E	NRL NEW	C	Leaf optics	8	Same species as LO #7 but more mature.
Yellow Flower Tree Bottom	29-May-09	1138	22.650148 S, 150.790937 E	NRL NEW	D	Leaf optics	14	Acacia plant. Above beach dune on FWB. East of beach entrance. Located 5/27/09
Yellow Flower Tree Flower	29-May-09	1146	22.650148 S, 150.790937 E	NRL NEW	D	Leaf optics	14	Acacia plant. Above beach dune on FWB. East of beach entrance. Located 5/27/09
Yellow Flower Tree Top	29-May-09	1131	22.650148 S, 150.790937 E	NRL NEW	D	Leaf optics	14	Acacia plant. Above beach dune on FWB. East of beach entrance. Located 5/27/09

APPENDIX F

Light Weight Deflectometer (LWD) Data

1. Introduction

A Light Weight Deflectometer (LWD) is an instrument for measuring the dynamic deflection modulus of a substrate. Components of the LWD include a weight-fix-and-release mechanism, guide rod, falling weight, steel spring, and a base plate with an embedded accelerometer. Once the weight drops, the spring provides the buffer system that transmits the load pulse to the plate resting on the material to be tested. The weight is raised to a fixed height that, when dropped, will impart a standardized force pulse. After the weight has recoiled from the base plate, the resulting vertical surface deflection is measured.

The Zorn ZFG 2000 light weight drop tester is the LWD used to conduct plate-bearing tests during the TS'09 experiment. It is configured with a 10-Kg (22.05 lbs) weight and a 300 mm (11.8 in) diameter plate. The LWD was used to measure bearing capacity (dynamic deflection modulus), one of the two failure mechanisms of soil under load. It is highly portable and was easily transported around the coastal zone. The Zorn ZFG 2000 provides a simple way to estimating bearing capacity and the recorder/printer device gives hard copy results in the field as well as recording data onto a chip card for uploading to a PC. A complete test cycle can be completed in less than a minute.

The LWD measures the *in situ* dynamic deflection modulus of soils. The influence depth is approximately 1 to 1.5 times the plate diameter. Results from TS09 are provided below in table and chart format.

2. Light Weight Deflectometer Tabular Data

The tables below present the LWD findings for all GPS points in which LWD measurement was taken. The LWD Evd values were then broken into five bins; "Excellent," (Evd> 28.3 MNm^{-2}), "Good," (21.6 MNm^{-2}< Evd ≤ 28.3 MNm^{-2}), "Fair," (14.9 MNm^{-2}< Evd ≤ 21.6 MNm^{-2}), "Poor," (8.2 MNm^{-2}< Evd ≤ 14.9 MNm^{-2}), and "Bad," (Evd ≤ 8.2 MNm^{-2}).

2.1. Cape Clinton Pocket Beach: 19 May 2009

No. (of test)	Local Date	Local Time	Deflection [mm]				Evd [MN/m²]	Site Name	LWD	Notes	Trafficability Condition
			single values			mean					
			s1	s2	s3	s					
1	19 May 2009	14:50	2.232	1.678	1.589	1.833	12.3	PB1-01	2	pocket beach	Poor
2	19 May 2009	14:54	2.784	1.952	1.768	2.168	10.4	PB1-02	2	pocket beach	Poor
3	19 May 2009	15:03	2.426	1.902	1.564	1.964	11.5	PB1-03	2	pocket beach	Poor
4	19 May 2009	15:09	3.958	2.079	1.745	2.594	8.7	PB1-04	2	pocket beach	Poor
5	19 May 2009	15:15	3.715	1.900	1.420	2.345	9.6	PB1-05	2	pocket beach	Poor
6	19 May 2009	15:26	4.013	1.359	1.163	2.178	10.3	PB1-06	2	pocket beach	Poor
7	19 May 2009	15:28	2.863	1.182	1.119	1.721	13.1	PB1-07	2	pocket beach	Poor
8	19 May 2009	15:30	3.697	1.407	1.186	2.097	10.7	PB1-08	2	pocket beach	Poor
9	19 May 2009	15:35	2.762	1.524	1.280	1.855	12.1	PB1-09	2	pocket beach	Poor
10	19 May 2009	15:39	6.284	6.034	5.547	5.955	3.8	PB1-10	2	pocket beach	Bad
11	19 May 2009	15:42	9.352	6.811	5.808	7.324	3.1	PB1-11	2	pocket beach	Bad
12	19 May 2009	15:47	10.636	9.140	8.014	9.263	2.4	PB1-12	2	pocket beach	Bad
13	19 May 2009	15:51	8.223	7.628	7.083	7.645	2.9	PB1-13	2	pocket beach	Bad
14	19 May 2009	15:55	10.330	5.124	4.666	6.707	3.4	PB1-14	2	pocket beach	Bad
15	19 May 2009	15:59	6.302	4.829	4.144	5.092	4.4	PB1-15	2	pocket beach	Bad

2.2 Freshwater Beach: 20-21 May 2009

No. (of test)	Local Date	Local Time	Deflection [mm]				Evd [MN/m²]	Site Name	LWD	Notes	Trafficability Condition
			single values			mean					
			s1	s2	s3	s					
22	20 May 2009	11:31	3.068	2.670	2.188	2.642	8.5	FWA-1A	1		Poor
23	20 May 2009	11:41	1.543	1.347	1.084	1.325	17.0	FWA-1B	1		Fair
27	20 May 2009	13:31	1.586	0.896	0.831	1.104	20.4	FWA-1C	1		Fair
26	20 May 2009	13:25	1.499	1.178	1.064	1.247	18.0	FWA-1D	1		Fair
25	20 May 2009	13:21	1.547	1.306	1.268	1.374	16.4	FWA-1E	1		Fair
24	20 May 2009	13:06	1.401	1.143	1.107	1.217	18.5	FWA-1F	1		Fair
16	20 May 2009	12:32	9.313	2.894	3.021	5.076	4.4	FWB-B1A	2		Bad
17	20 May 2009	13:02	3.183	1.386	1.147	1.905	11.8	FWB-B2A	2		Poor
18	20 May 2009	13:14	1.845	1.053	0.997	1.298	17.3	FWB-B3A	2		Fair
19	20 May 2009	13:18	1.642	1.006	0.877	1.175	19.1	FWB-B4A	2	FWB-04	Fair
20	20 May 2009	13:21	1.654	1.102	1.007	1.254	17.9	FWB-B5A	2	FWB-05	Fair
21	20 May 2009	13:23	2.111	1.398	1.279	1.596	14.1	FWB-B6A	2	FWB-06B	Poor
1	21 May 2009	10:30	5.359	2.376	2.115	3.283	6.9	FWD-01	2		Bad
2	21 May 2009	10:39	10.362	4.347	3.771	6.160	3.7	FWD-02	2		Bad
3	21 May 2009	11:17	5.590	3.768	3.662	4.340	5.2	FWD-03	2		Bad
4	21 May 2009	11:31	9.120	4.716	4.006	5.947	3.8	FWD-04	2		Bad
5	21 May 2009	12:07	6.903	3.398	2.616	4.306	5.2	FWD-05	2		Bad
6	21 May 2009	12:13	2.335	1.405	1.257	1.666	13.5	FWD-06	2		Poor
3	21 May 2009	11:02	13.631	3.913	3.687	7.077	3.2	FWA-3A	1		Bad
2	21 May 2009	10:54	3.969	3.569	3.269	3.602	6.2	FWA-3B	1		Bad
1	21 May 2009	10:38	0.963	0.767	0.700	0.810	27.8	FWA-3C	1		Good
7	21 May 2009	12:57	1.612	0.799	0.755	1.055	21.3	FWA-3D	1		Fair
6	21 May 2009	12:49	1.453	1.186	1.080	1.240	18.1	FWA-3E	1		Fair
5	21 May 2009	12:34	0.894	0.822	0.781	0.832	27.0	FWA-3F	1		Good
4	21 May 2009	12:16	0.888	0.886	0.892	0.889	25.3	FWA-3G	1		Good

2.3. Freshwater Beach: 22 May 2009

No. (of test)	Local Date	Local Time	Deflection [mm]				Evd [MN/m²]	Site Name	LWD	Notes	Trafficability Condition
			single values			mean					
			s1	s2	s3	s					
7	22 May 2009	11:19	7.379	3.374	3.094	4.616	4.9	FWA5A	1		Bad
6	22 May 2009	11:14	8.317	3.405	3.238	4.987	4.5	FWA5C	1		Bad
5	22 May 2009	11:07	6.351	3.249	3.175	4.258	5.3	FWA5D	1		Bad
4	22 May 2009	10:50	0.850	0.677	0.621	0.716	31.4	FWA5E	1		Excellent
3	22 May 2009	10:37	0.775	0.622	0.574	0.657	34.2	FWA5F	1		Excellent
2	22 May 2009	10:29	0.873	0.810	0.775	0.819	27.5	FWA5G	1		Good
1	22 May 2009	10:21	1.049	0.912	0.870	0.944	23.8	FWA5H	1		Good
8	22 May 2009	12:47	6.843	3.586	3.238	4.556	4.9	FWA5I	1		Bad
9	22 May 2009	12:53	7.002	5.928	4.827	5.919	3.8	FWA5J	1		Bad
1	22 May 2009	9:43	3.131	3.028	2.574	2.911	7.7	FWB-5A	2	1st attempt	Bad
2	22 May 2009	9:46	10.866	3.832	2.908	5.869	3.8	FWB-5A	2	2nd attempt	Bad
3	22 May 2009	9:52	4.930	3.974	3.387	4.097	5.5	FWB-5B	2		Bad
4	22 May 2009	9:57	10.247	3.387	2.737	5.457	4.1	FWB-5C	2		Bad
5	22 May 2009	11:27	6.991	3.470	3.178	4.546	4.9	FWB-5D	2		Bad
6	22 May 2009	11:33	2.015	0.975	0.836	1.275	17.6	FWB-5E	2		Fair
7	22 May 2009	11:46	0.968	0.678	0.630	0.759	29.6	FWB-5F	2	1st attempt	Excellent
8	22 May 2009	11:50	1.031	0.716	0.647	0.798	28.2	FWB-5F	2	2nd attempt	Good
9	22 May 2009	12:06	1.423	0.826	0.763	1.004	22.4	FWB-5G	2		Good

2.4. Sabina Point Beach: 23 May 2009

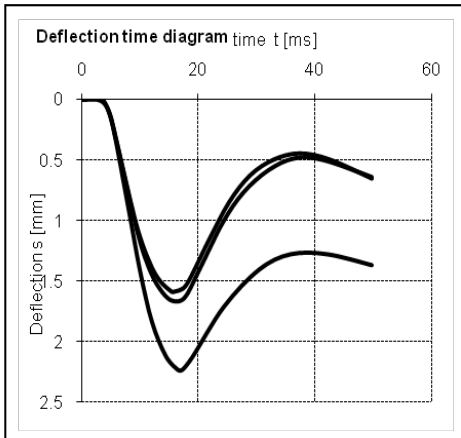
No.	Local Date	Local Time	Deflection [mm]				Evd [MN/m²]	Site Name	LWD	Notes	Trafficability Condition
			single values			mean					
			s1	s2	s3	s					
1	23 May 2009	10:10	6.9	4.3	4.0	5.0	4.5	SPB-1A	2		Bad
2	23 May 2009	10:19	4.1	3.5	2.9	3.5	6.4	SPB-1B	2		Bad
3	23 May 2009	10:37	15.5	8.9	8.4	10.9	2.1	SPB-1C	2		Bad
4	23 May 2009	10:40	5.8	2.9	2.5	3.7	6.1	SPB-1D	2		Bad
5	23 May 2009	10:50	2.5	1.9	1.7	2.0	11.1	SPB-1E	2		Poor
6	23 May 2009	10:55	3.4	2.3	1.8	2.5	8.9	SPB-1F	2		Poor
7	23 May 2009	11:25	4.9	3.0	2.5	3.4	6.5	SPB-1G	2		Bad
8	23 May 2009	11:40	3.2	2.6	2.4	2.8	8.1	SPB-1H	2		Bad
9	23 May 2009	13:12	1.5	1.3	1.3	1.4	16.6	SPB-1I	2		Fair
10	23 May 2009	13:22	2.2	1.4	1.2	1.6	14.1	SPB-1J	2		Poor
12	23 May 2009	14:04	4.4	2.5	2.2	3.0	7.4	SPB-1K	2	Dense rocks--see notes	Bad
11	23 May 2009	13:56	2.7	1.8	1.5	2.0	11.2	SPB-1L	2	Dense rocks--see notes	Poor
13	23 May 2009	14:19	8.1	6.3	5.9	6.8	3.3	SPB-1M	2		Bad
14	23 May 2009	15:04	5.9	4.2	3.9	4.7	4.8	SPB-1N	2		Bad
15	23 May 2009	15:23	4.6	4.2	4.1	4.3	5.2	SPB-1O	2		Bad
16	23 May 2009	15:30	6.9	6.7	6.7	6.8	3.3	SPB-1P	2		Bad

2.5. Cape Clinton Pocket Beach: 28 May 2009

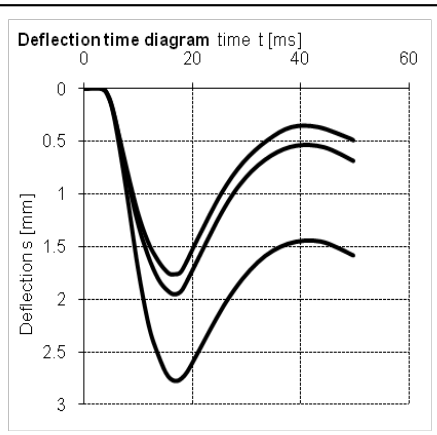
19	28 May 2009	11:02	2.1	1.4	1.5	1.6	13.7	PBJ-1A	2		Poor
20	28 May 2009	11:20	2.7	1.7	1.7	2.0	11.1	PBJ-1B, drop 1	2		Poor
21	28 May 2009	11:22	3.0	1.9	1.7	2.2	10.2	PBJ-1B, drop 2	2		Poor
22	28 May 2009	11:40	2.1	1.5	1.4	1.7	13.3	PBJ-1C	2		Poor
23	28 May 2009	12:09	3.0	1.9	1.8	2.2	10.1	PBJ-1D	2		Poor
24	28 May 2009	12:25	9.5	8.2	7.2	8.3	2.7	PBJ-1E	2		Bad
25	28 May 2009	12:55	14.0	11.2	9.7	11.6	1.9	PBJ-1F	2		Bad
26	28 May 2009	12:57	10.0	4.6	2.0	5.5	4.1	PBJ-1G, drop 1	2		Bad
27	28 May 2009	12:59	7.0	4.4	4.3	5.2	4.3	PBJ-1G, drop 2	2		Bad

3. Light Weight Deflectometer Graphical Data

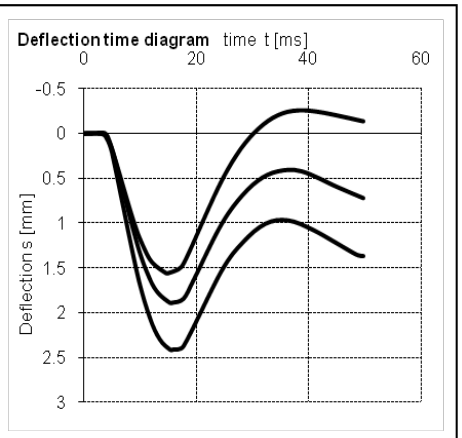
3.1. Cape Clinton Pocket Beach: 19 May 2009



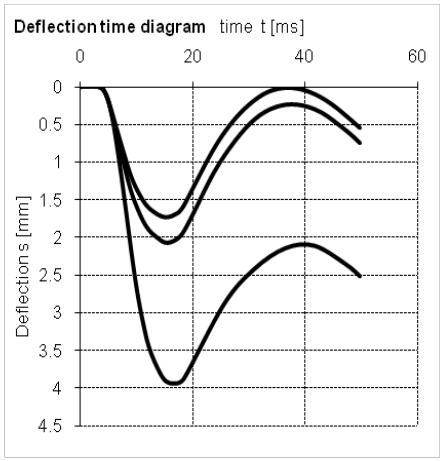
PB1-01



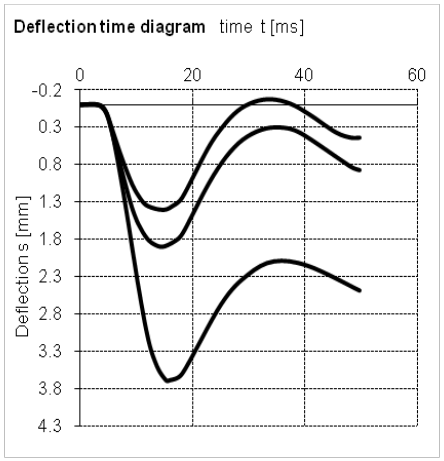
PB1-02



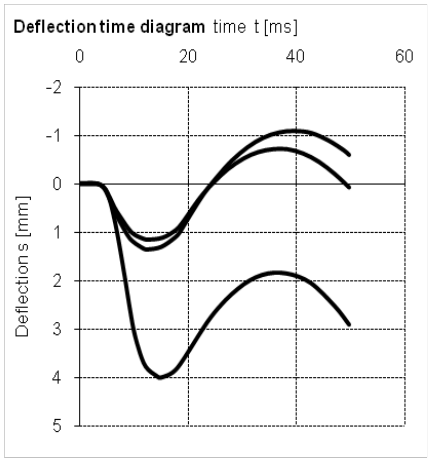
PB1-03



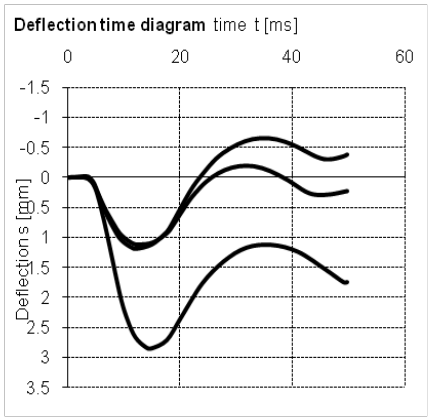
PB1-04



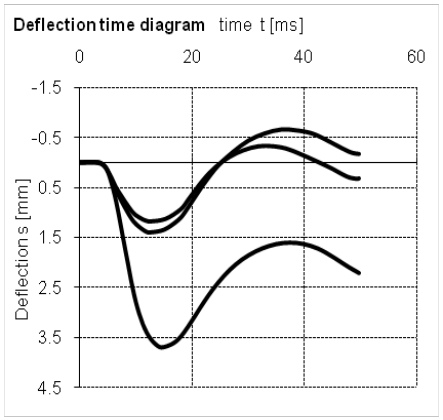
PB1-05



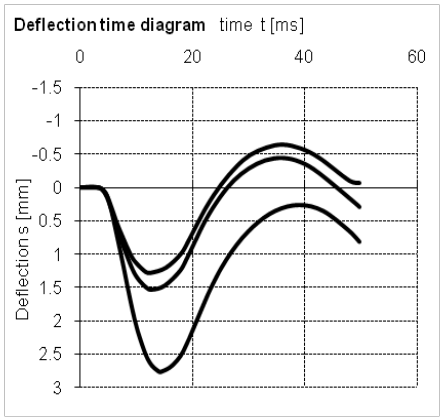
PB1-06



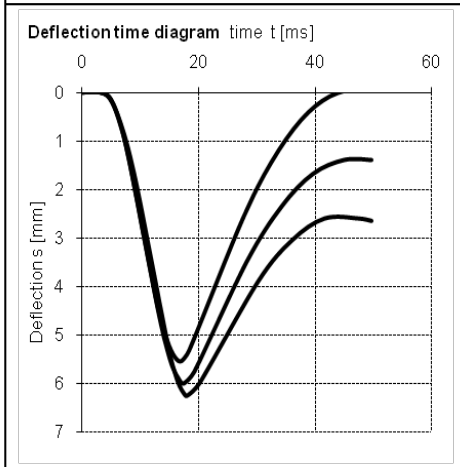
PB1-07



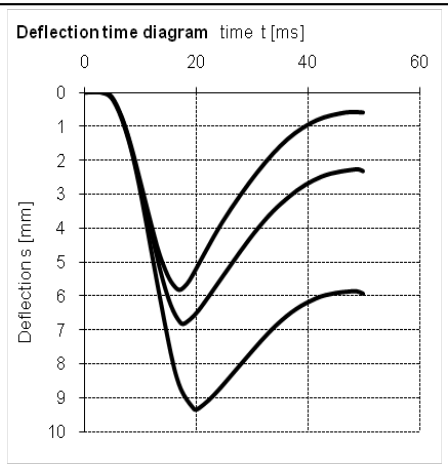
PB1-08



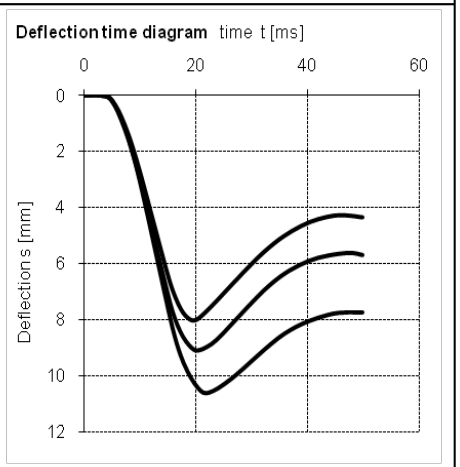
PB1-09



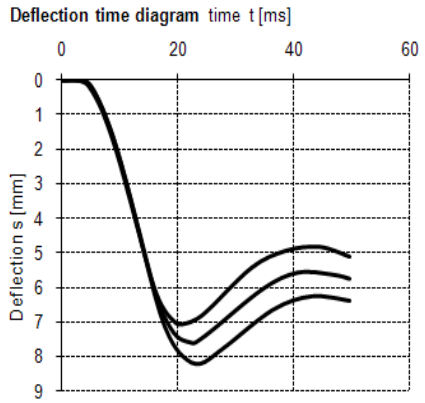
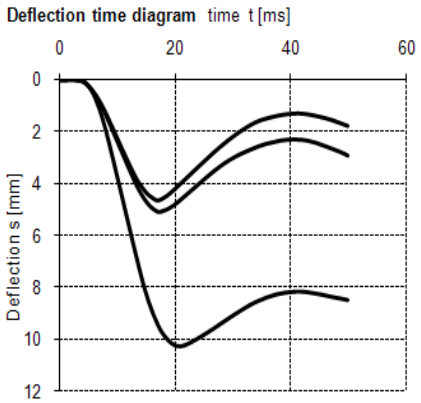
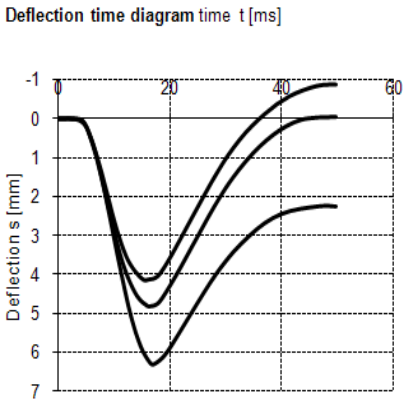
PB1-10



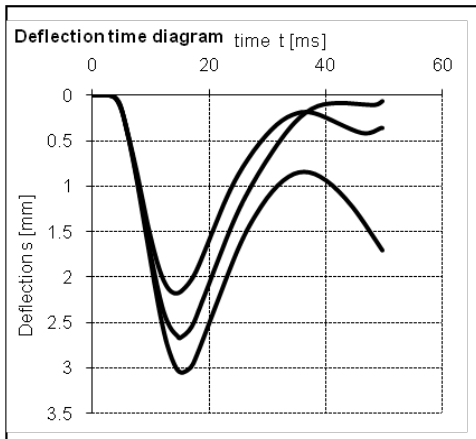
PB1-11



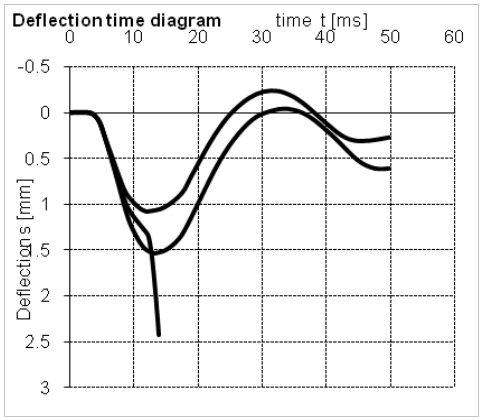
PB1-12

		
PB1-13	PB1-14	PB1-15

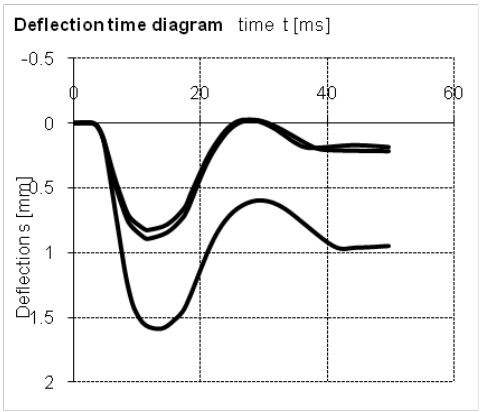
3.2. Freshwater Beach: 20 May 2009-FWA Series



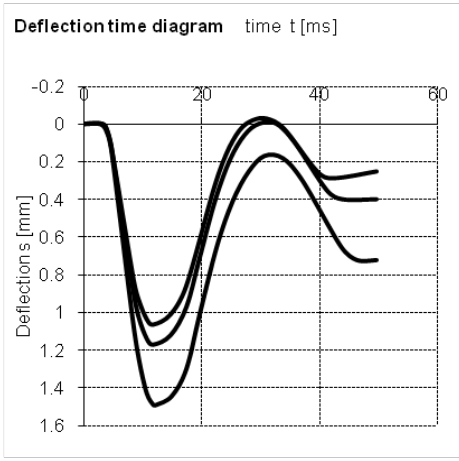
FWA-1A



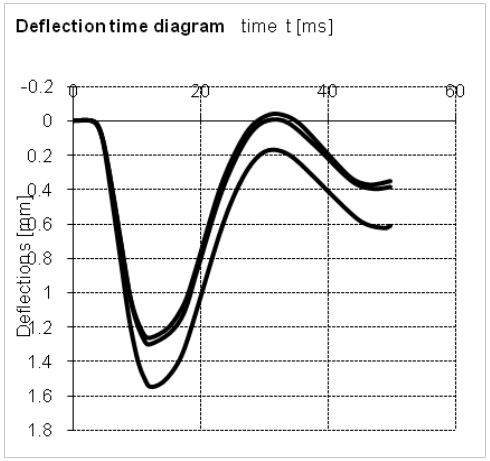
FWA-1B



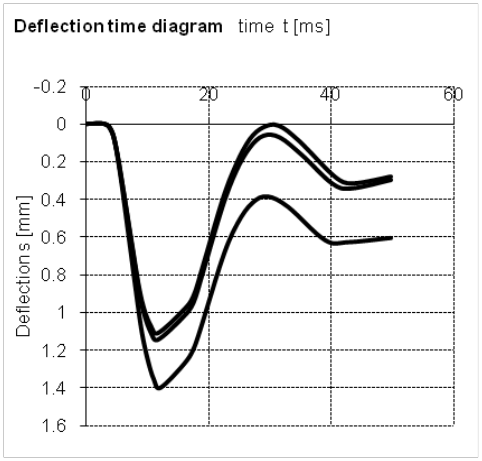
FWA-1C



FWA-1D

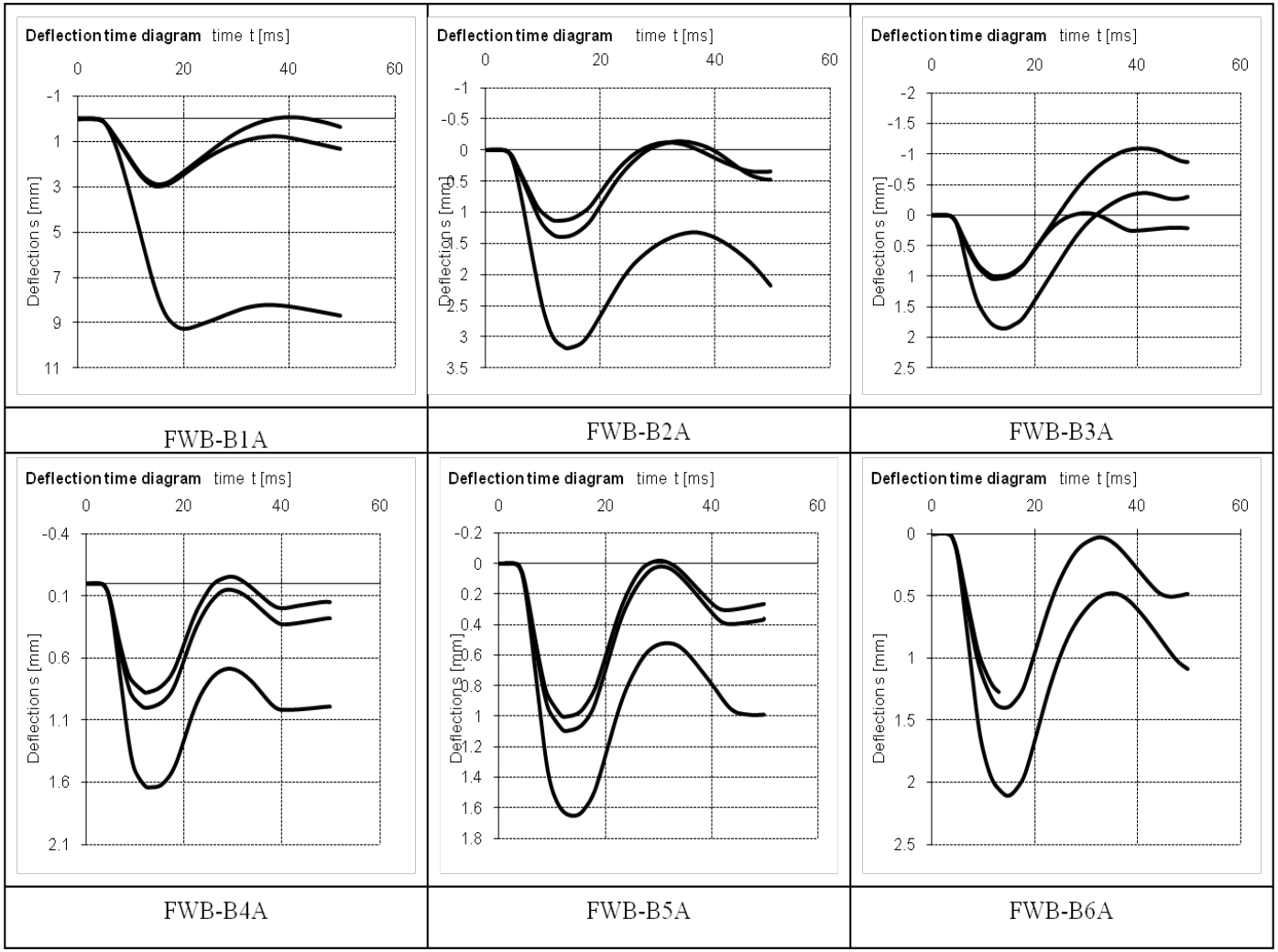


FWA-1E

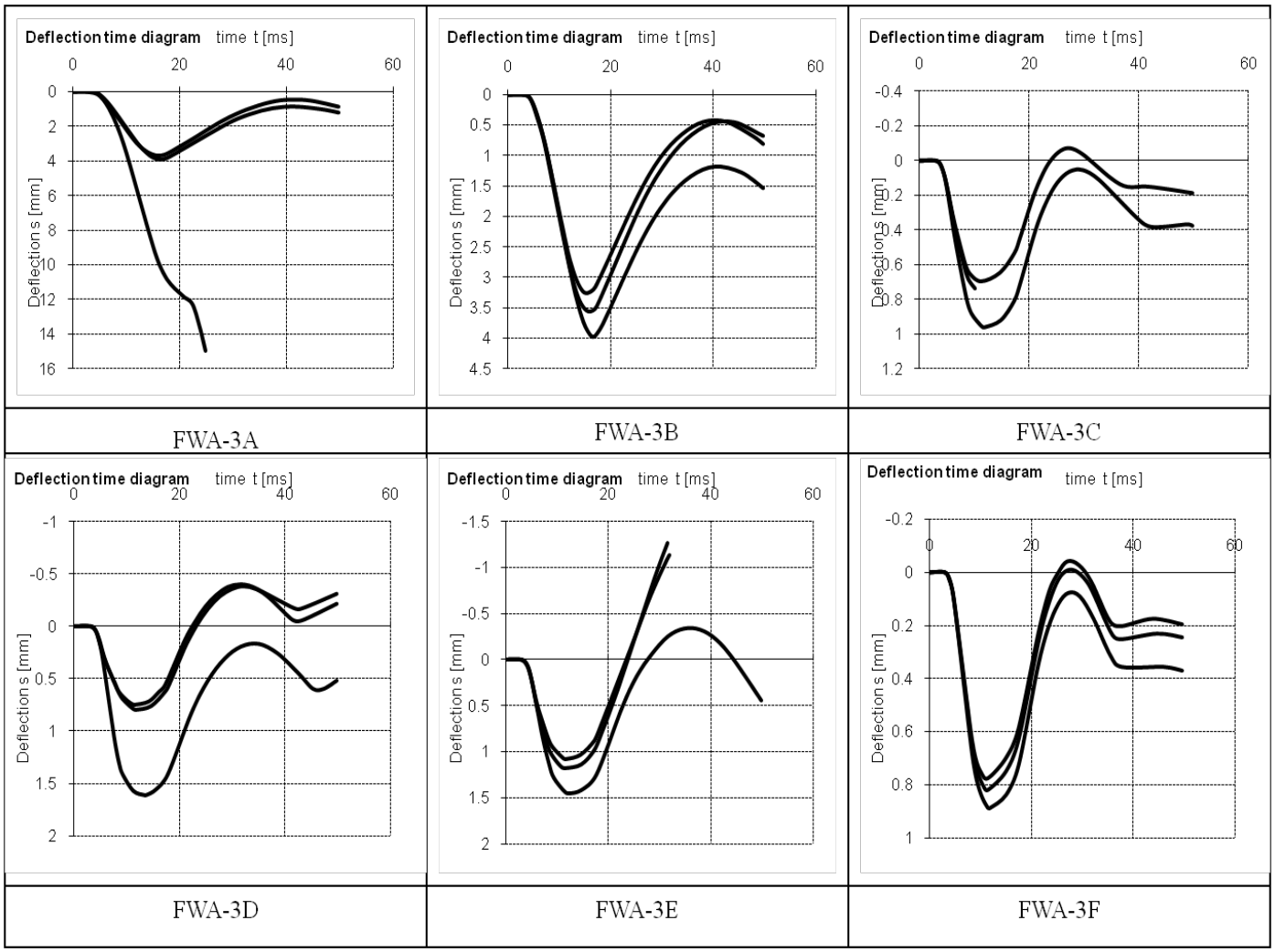


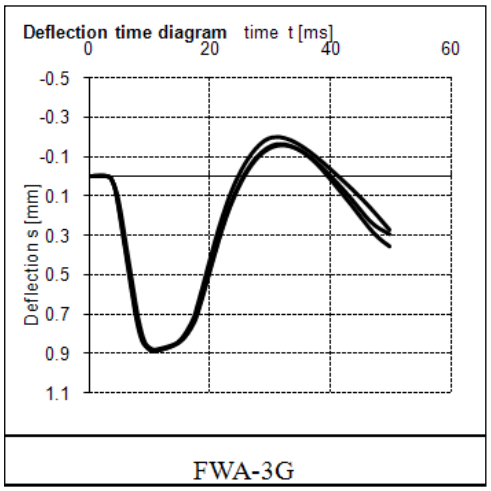
FWA-1F

3.3. Freshwater Beach: 20 May 2009-FWB-B Series



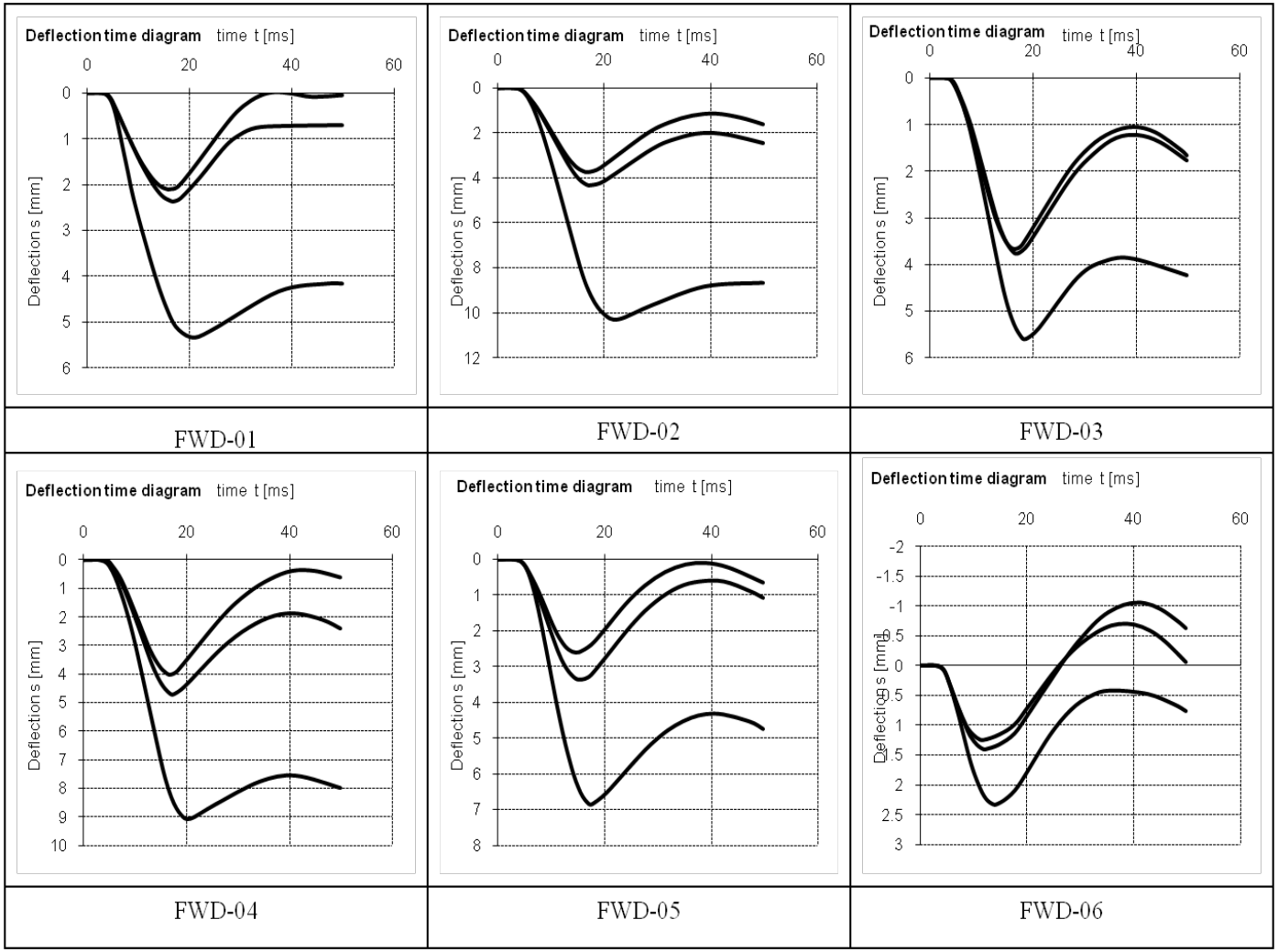
3.4. Freshwater Beach: 21 May 2009-FWA-3 Series



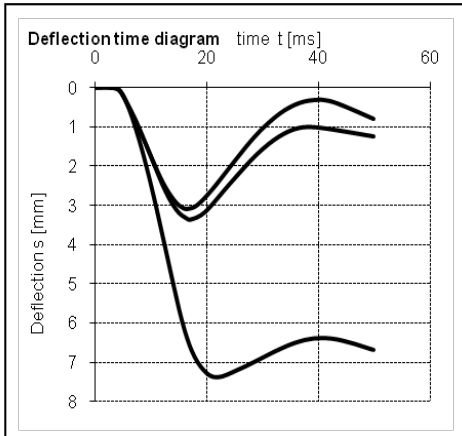

Deflection time diagram
time t [ms]
0
20
40
60
-0.5
-0.3
-0.1
0.1
0.3
0.5
0.7
0.9
1.1
Deflection s [mm]

FWA-3G

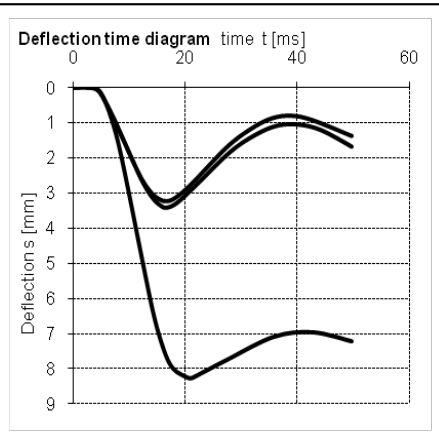
3.5. Freshwater Beach: 21 May 2009-FWD Series



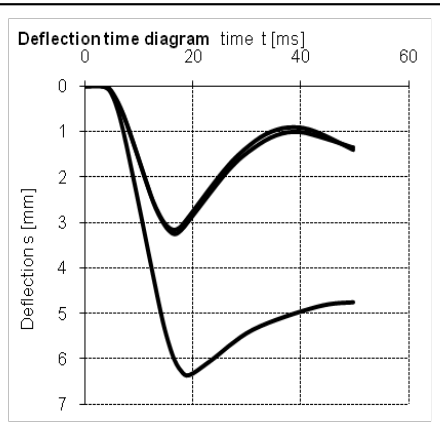
3.6. Freshwater Beach: 22 May 2009-FWA Series



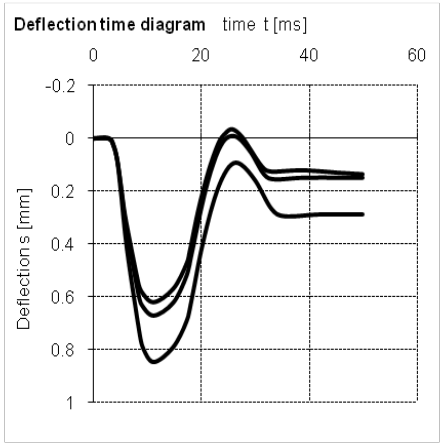
FWA-5A



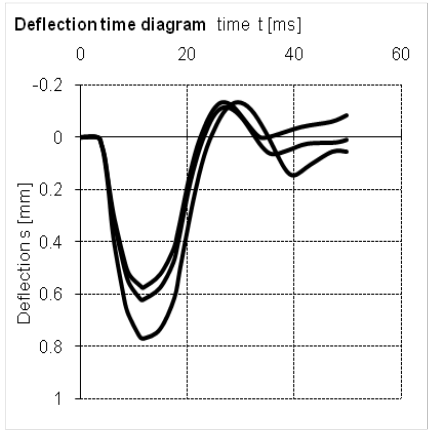
FWA-5C



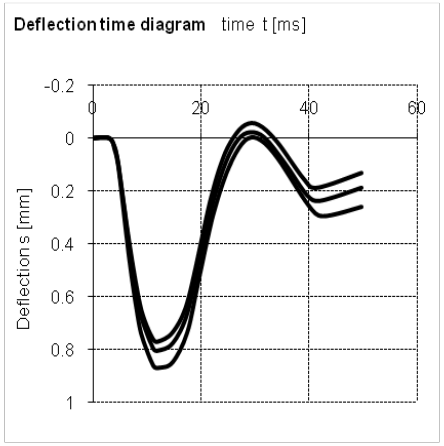
FWA-5D



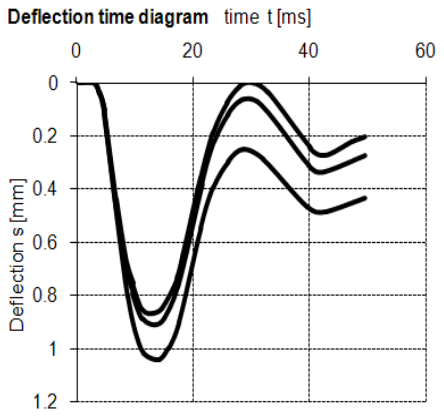
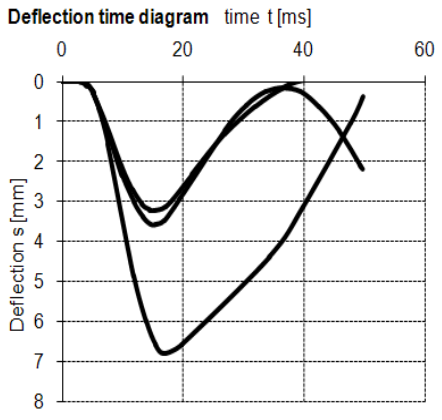
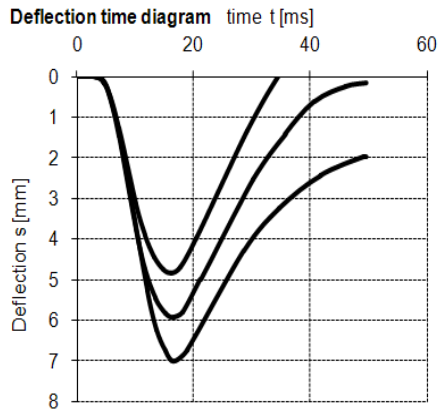
FWA-5E



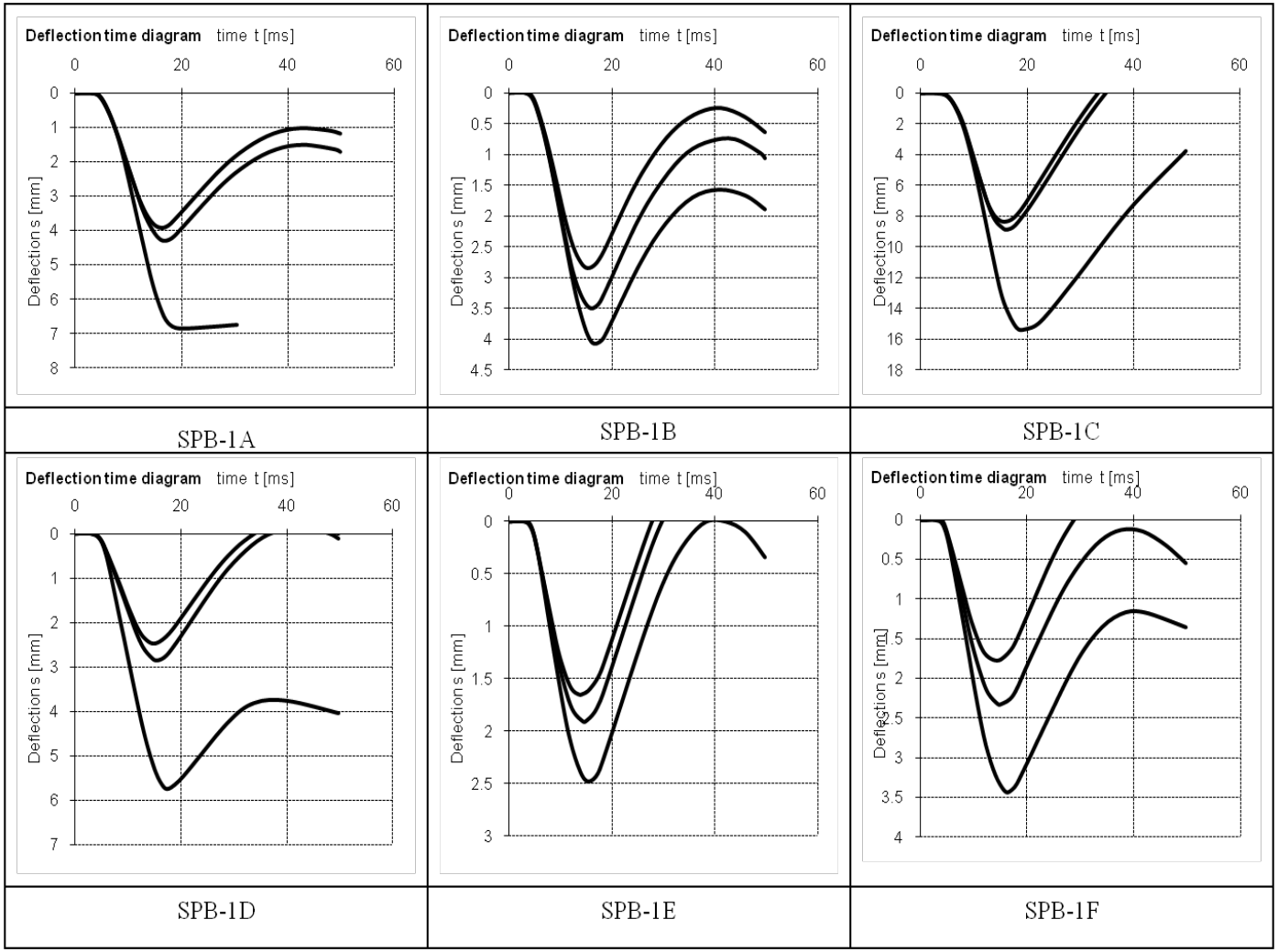
FWA-5F

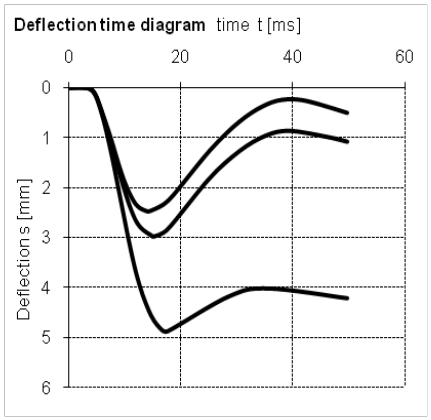


FWA-5G

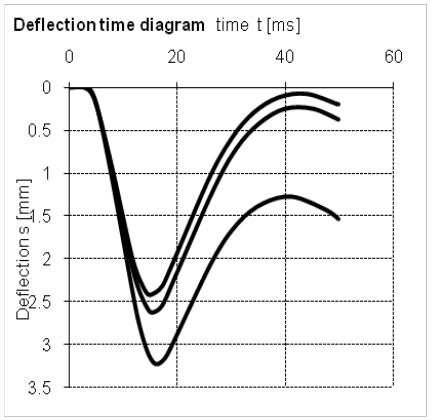
		
FWA-5H	FWA-5I	FWA-5J

3.7. Sabina Point: 23 May 2009-SPB-1 Series

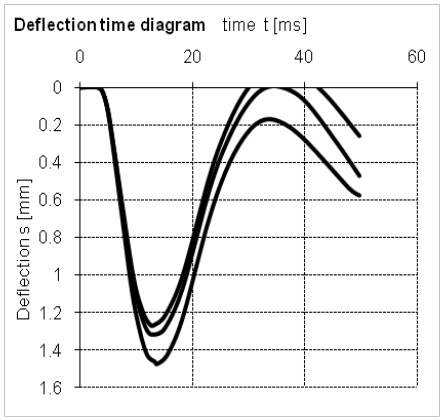




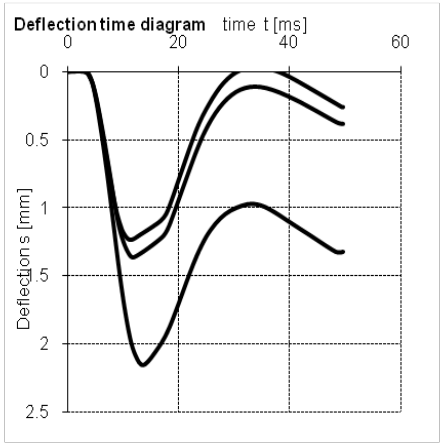
SPB-1G



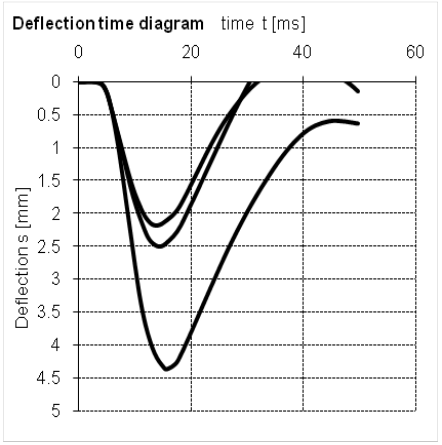
SPB-1H



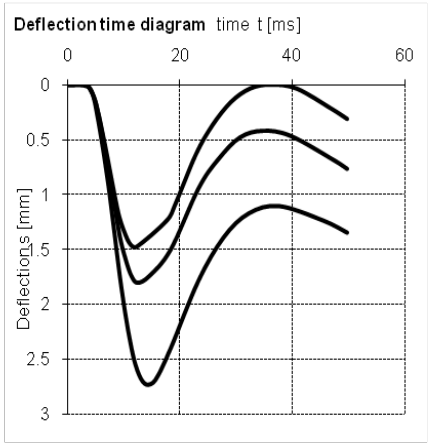
SPB-1I



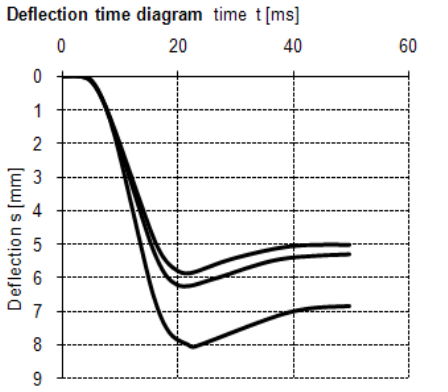
SPB-1J



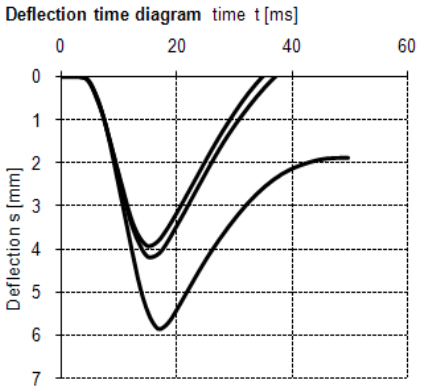
SPB-1K



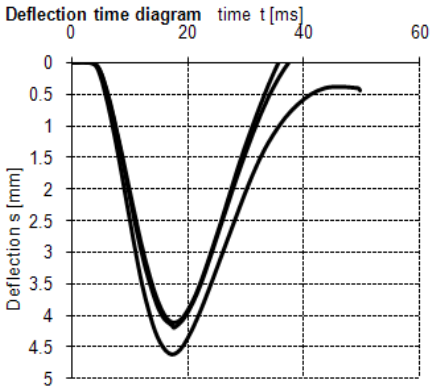
SPB-1L



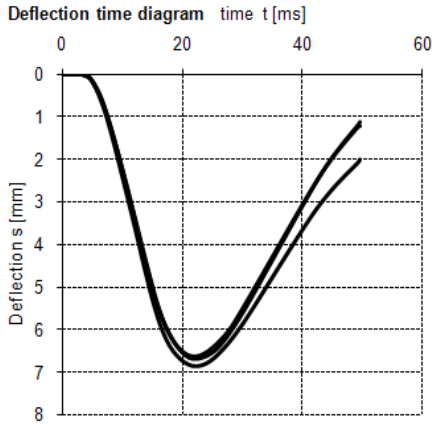
SPB-1M



SPB-1N

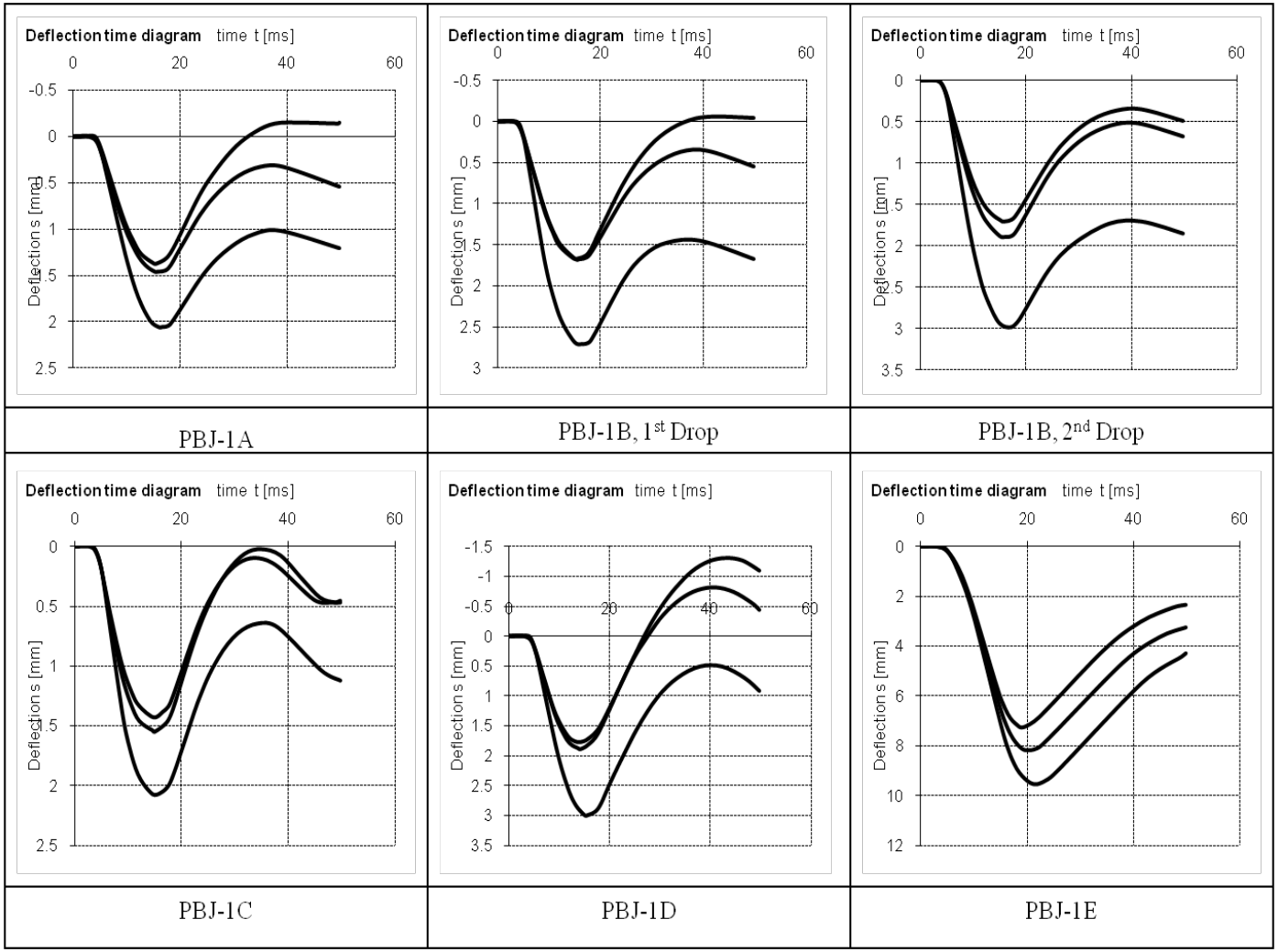


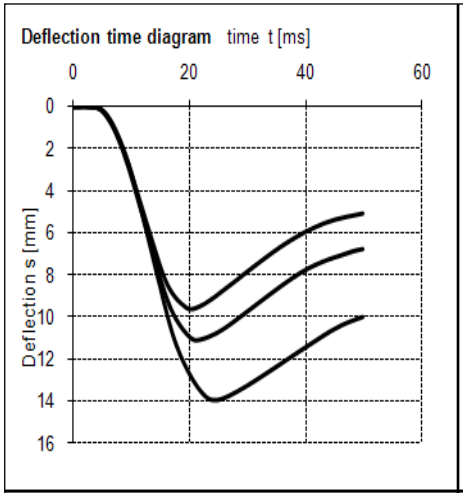
SPB-1O



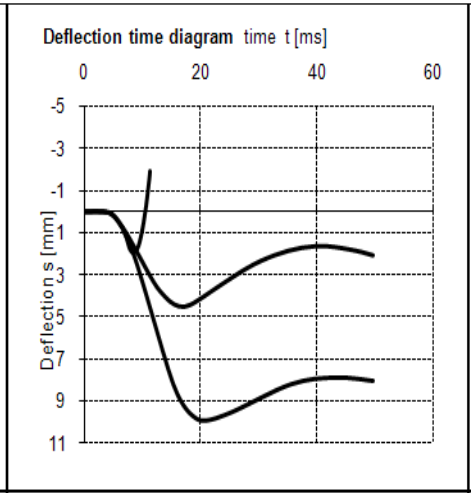
SPB-1P

3.8. Cape Clinton Pocket Beach: 28 May 2009-PBJ-1 Series

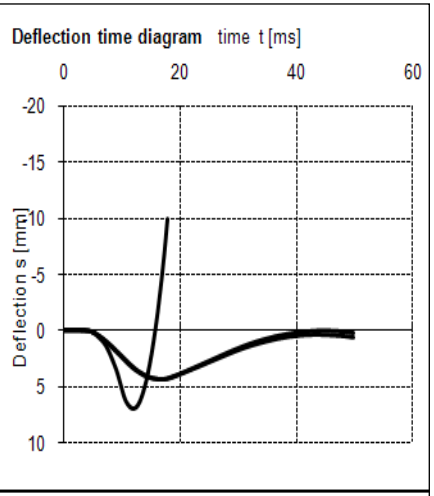




PBJ-1F



PBJ-1G, 1st Drop



PBJ-1G, 2nd Drop

APPENDIX G

California Bearing Ratio

---

1. Introduction

California Bearing Ratio (CBR) is used as an empirical measurement of shear strength, one of the two failure mechanisms of soil under load. Combat engineers from Marine Wing Support Squadrons determine soil strength or bearing capacity values for expeditionary airfields before the beginning of aircraft operations. At bases and stations, physical scientists or specially trained civil engineer personnel may conduct these evaluations. In hostile situations, combat engineers attempt to conduct the evaluations under adverse conditions. Basically, the engineers determine strength using a Dynamic Cone Penetrometer (DCP), and then correlate the DCP readings to a CBR value for use in supporting operations.

The DCP is the current USMC and USAF standard for measurement of bearing strength for airfields. The use of the DCP is described in ASTM D 6951-03 (American Society for Testing and Materials 2003). The dual-mass DCP consists of a 5/8-in.-diameter steel rod with a steel cone attached to one end, which is driven into the soil by means of a sliding dual-mass hammer. The angle of the cone is 60°, and the diameter of the base of the cone is 0.79 in. For TS09, the DCP was driven into the ground by dropping a 10.1-lb sliding hammer from a height of 22.6 in. The depth of cone penetration is measured at selected penetration or hammer-drop intervals and the soil shear strength is reported as the DCP index in millimeters/blow. Dynamic Cone Penetrometer test data are recorded in two columns, where the first column is number of blows and the second column is cumulative penetration in mm. In accordance with Army Field Manuals, CBR is computed using the following empirical equations

$$CBR = 292 / PR^{1.12}$$

$$\text{CL soils: } CBR < 10: CBR = 1 / (0.017019*PR)^2$$

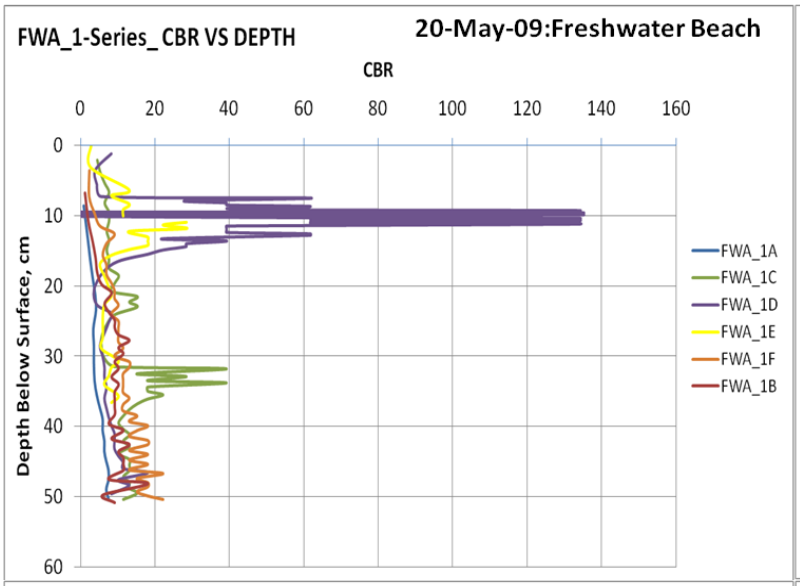
$$\text{CH soils: } CBR = 1/ (0.002871*PR)$$

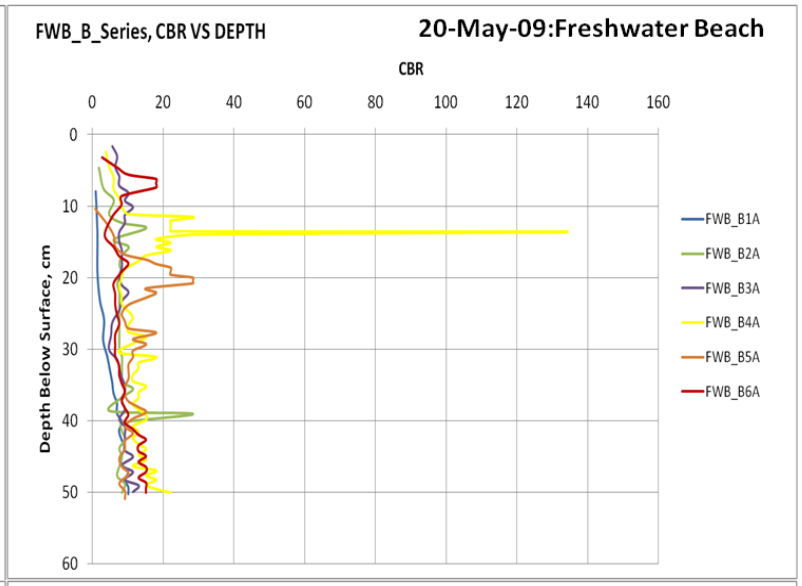
where

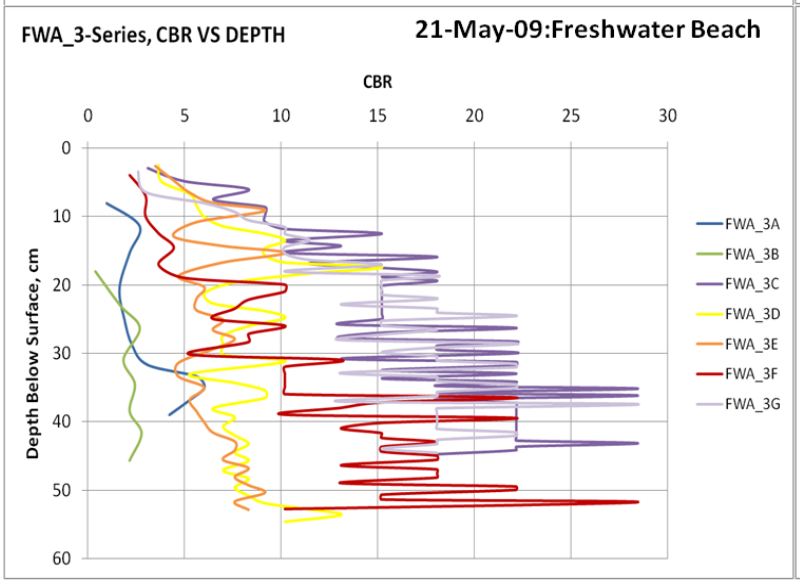
- PR is the DCP penetration rate in mm per blow.
- CL soils are gravelly clays, sandy clays, silty clays, and lean clays.
- CH soils are inorganic clays of high plasticity, including fat clays, gumbo clays, volcanic clays, and bentonite.

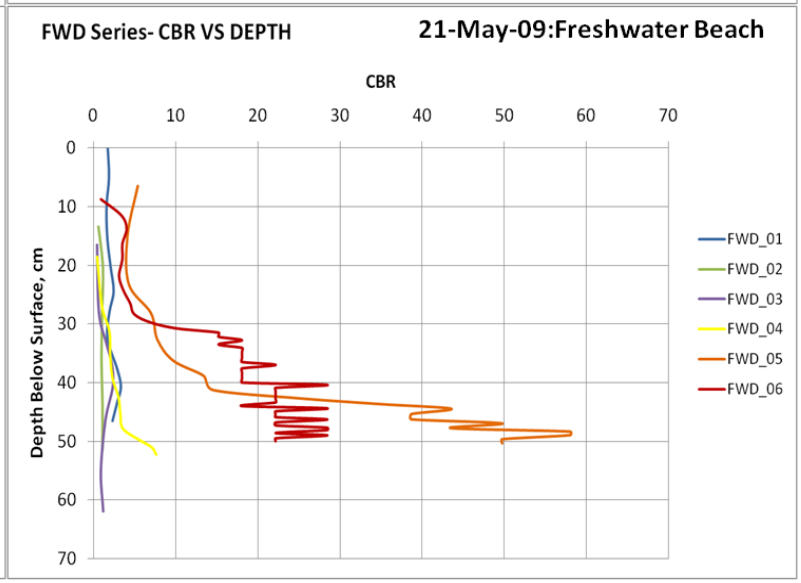
TS09 demonstrated the utility of measuring CBR as a component of littoral penetration point classification and as a trafficability parameter. The CBR was plotted against depth (cm) and can be seen below in Section 2 for each substrate sample position where GPS was used to record position on the coast. In the graphs on the following pages, the CBR is plotted on the x-axis and the depth below the surface in centimeters is plotted on the y-axis. Please note the x and y axes' scale changes among the figures.

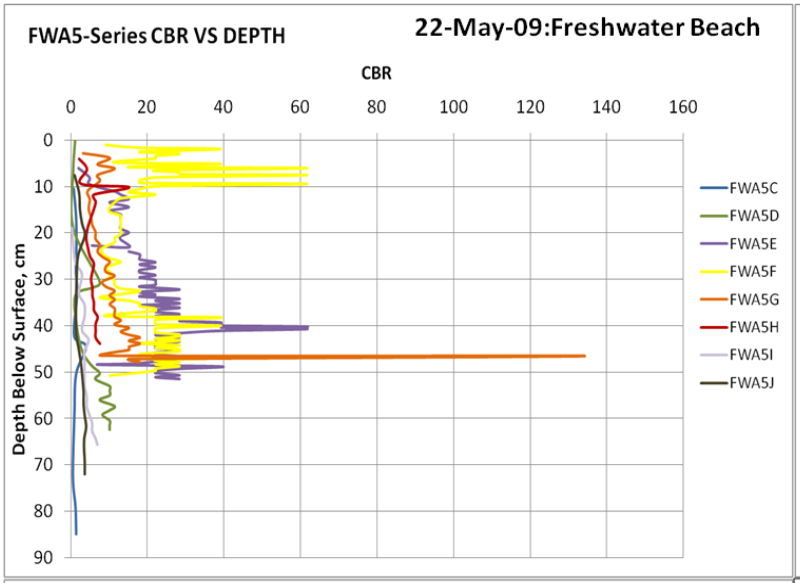
2. California Bearing Ratio Figures

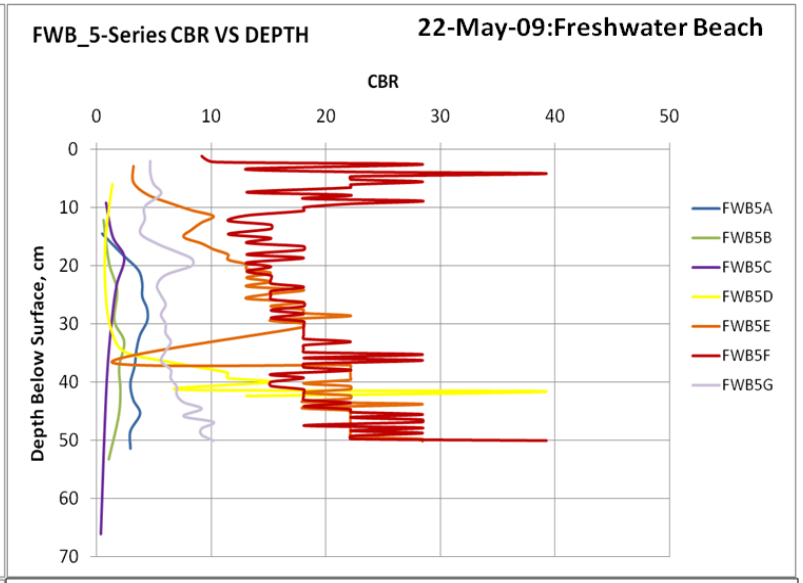


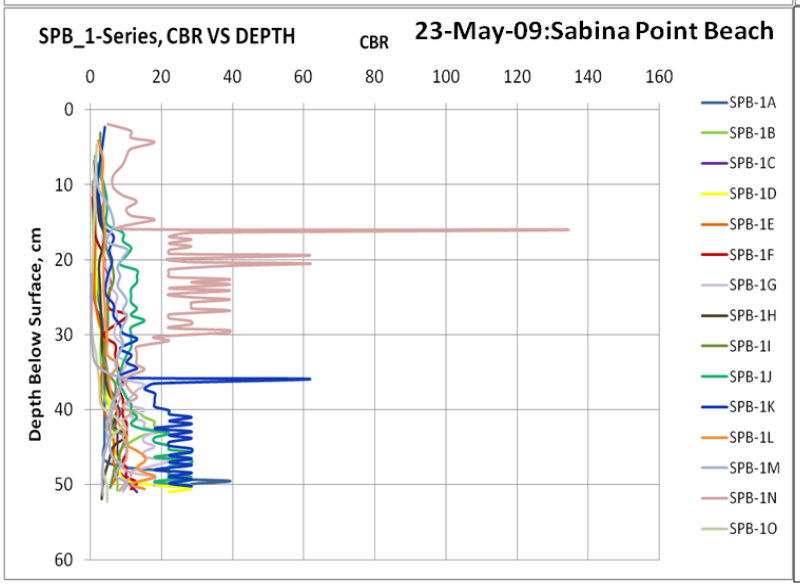


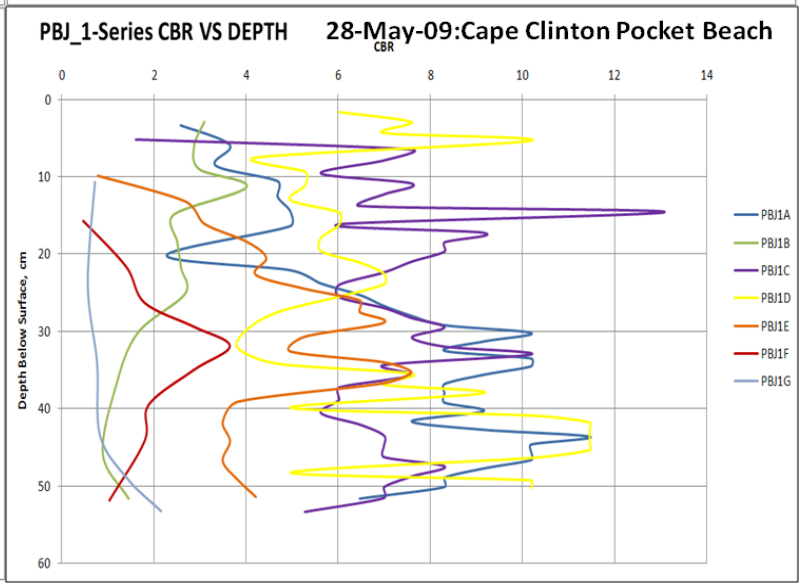





FWA5-Series CBR VS DEPTH
22-May-09:Freshwater Beach
CBR
0 20 40 60 80 100 120 140 160
Depth Below Surface, cm
0 10 20 30 40 50 60 70 80 90
FWA5C
FWA5D
FWA5E
FWA5F
FWA5G
FWA5H
FWA5I
FWA5J


FWB_5-Series CBR VS DEPTH
22-May-09:Freshwater Beach
CBR
0 10 20 30 40 50
Depth Below Surface, cm
0 10 20 30 40 50 60 70
FWB5A
FWB5B
FWB5C
FWB5D
FWB5E
FWB5F
FWB5G


SPB_1-Series, CBR VS DEPTH
CBR
23-May-09:Sabina Point Beach
0 20 40 60 80 100 120 140 160
Depth Below Surface, cm
0 10 20 30 40 50 60
SPB-1A
SPB-1B
SPB-1C
SPB-1D
SPB-1E
SPB-1F
SPB-1G
SPB-1H
SPB-1I
SPB-1J
SPB-1K
SPB-1L
SPB-1M
SPB-1N
SPB-1O


PBJ_1-Series CBR VS DEPTH
28-May-09:Cape Clinton Pocket Beach
CBR
0 2 4 6 8 10 12 14
Depth Below Surface, cm
0 10 20 30 40 50 60
PBJ1A
PBJ1B
PBJ1C
PBJ1D
PBJ1E
PBJ1F
PBJ1G

APPENDIX H

Other Soil Properties

1. Introduction

Determining beach composition was an essential TS'09 task involving the collection of "grab samples" across the beach. Two of four standard soil tests were accomplished: (1) moisture content determinations and (2) grading or sieve analysis. Future studies will include (3) basic properties tests, and (4) density standards and density determination tests. Sample locations were chosen that were representative of regions such as the beach face, foreshore, dune field, low marsh, high marsh, etc. If there was a major change in soil type, then the area was broken into sub-sites for sampling. Soil samples were collected with a corer to a critical depth of 3 inches (7.62cm). Samples are collected as quickly as possible and stored in either zip-loc bags or sediment corer tubes. This prevents the loss of moisture to evaporation. When possible, samples were placed in a cooler to keep the samples at a moderate temperature. Samples were then taken to the lab to determine soil moisture and grain size distributions.

2. Soil Moisture Determination

2.1 Preparing the Soil Samples

After soil samples were taken to the lab, quick and careful procedures were taken to determine soil moisture. The moisture content is expressed as a percentage and is the mass of water divided by the dry mass of soil times one hundred. The following steps occurred:

1. We opened windows to ensure good ventilation because of fumes from microwave baking of soil samples.
2. The weighing container was weighed prior to putting soil on the container. This value is needed for the calculation of soil moisture.
3. Approximately 25 grams of wet/moist soil were placed on the container and the weight of soil and container were measured.
4. Drying the sample was done with a microwave oven. The microwave oven is faster for drying then using a field moisture oven. The appropriate steps for drying with a microwave oven are as follows:

2.2 Soil Sample Drying in a Microwave Oven

A. Place sample into microwave with a heat sink (brick) and run the microwave oven for 6 minutes.
B. Weigh the sample and return to microwave oven for 1 minute and reweigh. If the weight of the sample has changed, return to the microwave oven for 1 more minute.
C. Repeat the process until a constant weight is achieved.
D. Record the following measurements

- (net weight) - (weight of container) = net soil weight
- (dry weight) - (weight of container) = dry soil weight
- (net soil weight) - (dry soil weight) = water weight

- (water weight) ÷ (dry soil weight) = soil water content

(Typical drying times for a wet sample are less than 20 minutes. Water is the first component of the soil to heat and evaporate. If the sample is dry and microwave drying continues, the soil temperature will increase and oxidize organic matter. This is to be avoided as it would bias results.)

3. Grain Size Distributions

After soil moisture is determined, samples are graded using a stack of appropriately sized sieves. For civil engineering applications, a certain series of sizes has come to be standard. Those most commonly used to grade materials have openings varying from 125mm down to 0.075mm and are stacked one on top of the other; in our experiments we added sieves for particles as small as 0.027 mm (27 microns) (Tests are often described by identifying sieve sizes by their opening in millimeters followed by English aperture size: for example, 4.75mm (No. 4) sieve. All sieves have square openings.) For beach composition, the grading analysis is the most important of all the soil tests, since factors such as beach gradient can be estimated from grain size. In order to grade the sample properly, the sieving operation uses a mechanical shaker to obtain lateral, vertical, and jarring actions, which keep the sample moving continuously over the surface of the sieve. After sufficient shaking, the mass of each sieve size is determined on a scale or balance. Then, the total percentage of material passing each sieve is calculated. Percentages are calculated to the nearest whole number except for the amount of material finer than the 0.075mm (No. 200) sieve, which is reported to the nearest 0.1 percent. If the total amount of material finer than 0.075 mm (No. 200) sieve is desired, it is determined by adding the mass of material passing the 0.075mm (No. 200) sieve by dry sieving.

4. TS09 Data

Soil moisture and grain size data are provided below. Section 4.1 displays soil moisture data in tabular format (Tables 1-4). Section 4.2 displays soil grain size distributions in tabular format (Tables 5-9). In section 4.3, graphs display soil grain size distribution data with sieve size on the x-axis and % of weight on the y-axis.

4.1 Soil Moisture Data

Table 1. 20 May 2009- 21 May 2009. Freshwater Beach Soil Water %.

Date	Sample Name	Sample Depth (in)	Total Sample Wet Wt in bag (g)	Total Sample Dry Wt in bag (g)	Total Sample Water (%)
20 May 2009	FWA-1A	3"	575	560	2.68
20 May 2009	FWA-1B	3"	460	445	3.37
20 May 2009	FWA-1C	3"	555	430	29.07
20 May 2009	FWA-1D	3"	310	245	26.53
20 May 2009	FWA-1E	3"	505	400	26.25
20 May 2009	FWA-1F	3"	473	370	27.84
20 May 2009	FWB-01	3"	480	465	3.23
20 May 2009	FWB-02	3"	470	375	25.33
20 May 2009	FWB-03	3"	635	510	24.51
20 May 2009	FWB-04	3"	510	395	29.11
20 May 2009	FWB-05	3"	400	300	33.33
20 May 2009	FWB-06	3"	570	450	26.67
21 May 2009	FWA-3A	3"	720	705	2.13
21 May 2009	FWA-3B	3"	597	575	3.83
21 May 2009	FWA-3C	3"	860	700	22.86
21 May 2009	FWA-3D	3"	721	595	21.18
21 May 2009	FWA-3E	3"	785	635	23.62
21 May 2009	FWA-3F	3"	448	370	21.08
21 May 2009	FWA-3G	3"	667	540	23.52
21 May 2009	FWD-01	3"	458	445	2.92
21 May 2009	FWD-02	3"	545	525	3.81
21 May 2009	FWD-03	3"	730	695	5.04
21 May 2009	FWD-04	3"	520	505	2.97
21 May 2009	FWD-05	3"	800	760	5.26
21 May 2009	FWD-06	3"	540	475	13.68

Table 2. 22 May 2009. Freshwater Beach Soil Water %..

Date	Sample Name	Sample Depth (in)	Total Sample Wet Wt in bag (g)	Total Sample Dry Wt in bag (g)	Total Sample Water (%)
22 May 2009	FWA-5J	3"	590	565	4.42
22 May 2009	FWA-5I	3"	385	360	6.94
22 May 2009	FWA-5A	3"	650	610	6.56
22 May 2009	FWA-5B	3"	720	675	6.67
22 May 2009	FWA-5C	3"	455	420	8.33
22 May 2009	FWA-5D	3"	540	510	5.88
22 May 2009	FWA-5E	3"	685	545	25.69
22 May 2009	FWA-5F	3"	610	520	17.31
22 May 2009	FWA-5G	3"	745	595	25.21
22 May 2009	FWA-5H	3"	795	645	23.26
22 May 2009	FWB-5A	3"	430	405	6.17
22 May 2009	FWB-5B	3"	485	445	8.99
22 May 2009	FWB-5C	3"	610	565	7.96
22 May 2009	FWB-5D	3"	465	430	8.14
22 May 2009	FWB-5E	3"	580	445	30.34
22 May 2009	FWB-5F	3"	355	290	22.41
22 May 2009	FWB-5G	3"	655	565	15.93

Table 3. 23 May 2009. Sabina Point Soil Water %.

Date	Sample Name	Sample Depth (in)	Total Sample Wet Wt in bag (g)	Total Sample Dry Wt in bag (g)	Total Sample Water (%)
23 May 2009	SPB-1A	3"	388	388	0.00
23 May 2009	SPB-1B	3"	450	445	1.12
23 May 2009	SPB-1C	3"	490	475	3.16
23 May 2009	SPB-1D	3"	375	360	4.17
23 May 2009	SPB-1E	3"	300	290	3.45
23 May 2009	SPB-1F	3"	430	420	2.38
23 May 2009	SPB-1G	3"	465	385	20.78
23 May 2009	SPB-1H	3"	490	400	22.50
23 May 2009	SPB-1I	3"	560	435	28.74
23 May 2009	SPB-1J	3"	555	475	16.84
23 May 2009	SPB-1K	3"	560	480	16.67
23 May 2009	SPB-1L	3"	625	505	23.76
23 May 2009	SPB-1M	3"	500	345	44.93
23 May 2009	SPB-1N	3"	555	415	33.73
23 May 2009	SPB-1O	3"	570	450	26.67
23 May 2009	SPB-1P	3"	320	250	28.00

Table 4. 28 May 2009. Cape Clinton Pocket Beach Soil Water %.

Date	Sample Name	Sample Depth (in)	Total Sample Wet Wt in bag (g)	Total Sample Dry Wt in bag (g)	Total Sample Water (%)
28 May 2009	PBJ-1A	3"	803	608	32.07
28 May 2009	PBJ-1B	3"	590.6	447.5	31.98
28 May 2009	PBJ-1C	3"	534.8	407.5	31.24
28 May 2009	PBJ-1D	3"	517.6	402.4	28.63
28 May 2009	PBJ-1E	3"	484.7	384.7	25.99
28 May 2009	PBJ-1F	3"	334.4	295	13.36
28 May 2009	PBJ-1G	3"	401.5	378.1	6.19

4.2 Soil Grain Size Distribution Data

Table 5. 20 May 2009. Freshwater Beach Soil Grain Size Distribution.

Date	Sample Name	Soil Grain Size Distribution (%)										
		600um	425um	300um	150um	106um	90um	75um	63um	45um	27um	pan
20 May 2009	FWA-1A	0.05	0.18	6.36	80.37	12.25	0.54	0.25	0.00	0.00	0.00	0.00
20 May 2009	FWA-1B	0.07	0.43	4.05	88.82	6.38	0.25	0.00	0.00	0.00	0.00	0.00
20 May 2009	FWA-1C	2.66	2.29	8.61	56.57	27.71	1.75	0.42	0.00	0.00	0.00	0.00
20 May 2009	FWA-1D	17.35	7.47	14.62	42.26	15.19	1.76	0.57	0.24	0.09	0.07	0.16
20 May 2009	FWA-1E	32.34	4.39	7.71	36.66	14.81	2.37	1.00	0.32	0.09	0.09	0.12
20 May 2009	FWA-1F	10.13	4.29	10.13	56.70	15.00	2.42	0.74	0.19	0.09	0.09	0.14
20 May 2009	FWB-01	0.41	0.06	1.75	82.14	15.15	0.49	0.00	0.00	0.00	0.00	0.00
20 May 2009	FWB-02	0.00	2.23	6.22	78.08	13.46	0.00	0.00	0.00	0.00	0.00	0.00
20 May 2009	FWB-03	4.00	4.23	10.87	69.92	10.28	0.55	0.14	0.00	0.00	0.00	0.00
20 May 2009	FWB-04	6.11	3.82	8.35	50.89	27.99	2.67	0.18	0.00	0.00	0.00	0.00
20 May 2009	FWB-05	9.95	3.23	6.72	52.72	24.28	2.41	0.63	0.07	0.00	0.00	0.00
20 May 2009	FWB-06	6.77	4.81	10.80	55.65	19.39	2.05	0.53	0.00	0.00	0.00	0.00

Table 6. 21 May 2009. Freshwater Beach Soil Grain Size Distribution.

Date	Sample Name	Soil Grain Size Distribution (%)										
		600um	425um	300um	150um	106um	90um	75um	63um	45um	27um	pan
21 May 2009	FWA-3A	0.01	0.06	1.41	85.30	6.58	4.17	2.08	0.34	0.02	0.00	0.00
21 May 2009	FWA-3B	0.22	0.35	3.31	88.09	6.42	0.83	0.69	0.09	0.00	0.00	0.00
21 May 2009	FWA-3C	1.43	1.23	2.78	81.63	12.17	0.54	0.16	0.04	0.00	0.00	0.00
21 May 2009	FWA-3D	11.09	6.14	22.16	59.58	0.79	0.05	0.03	0.05	0.04	0.04	0.03
21 May 2009	FWA-3E	6.79	5.74	18.53	67.54	1.32	0.09	0.00	0.00	0.00	0.00	0.00
21 May 2009	FWA-3F	8.69	9.05	22.06	56.89	2.53	0.16	0.14	0.14	0.07	0.09	0.14
21 May 2009	FWA-3G	11.47	25.08	35.31	27.04	0.91	0.02	0.04	0.04	0.04	0.04	0.04
21 May 2009	FWD-01	0.26	0.40	1.39	89.02	5.27	2.23	1.28	0.15	0.00	0.00	0.00
21 May 2009	FWD-02	0.06	0.13	2.22	79.64	13.97	3.08	0.89	0.00	0.00	0.00	0.00
21 May 2009	FWD-03	0.29	0.46	5.19	80.92	6.79	3.87	2.25	0.23	0.00	0.00	0.00
21 May 2009	FWD-04	0.08	0.29	4.60	92.25	1.95	0.65	0.18	0.00	0.00	0.00	0.00
21 May 2009	FWD-05	0.14	0.72	3.84	94.91	0.33	0.00	0.01	0.01	0.02	0.02	0.01
21 May 2009	FWD-06	0.52	1.89	6.78	90.56	0.21	0.00	0.00	0.00	0.02	0.02	0.02

Table 7. 22 May 2009. Freshwater Beach Soil Grain Size Distribution.

Date	Sample Name	Soil Grain Size Distribution (%)										
		600um	425um	300um	150um	106um	90um	75um	63um	45um	27um	pan
22 May 2009	FWA-5A	0.15	0.05	1.22	86.52	6.66	3.11	1.96	0.29	0.02	0.00	0.00
22 May 2009	FWA-5B	0.04	0.01	1.23	95.11	1.86	0.97	0.65	0.10	0.00	0.00	0.00
22 May 2009	FWA-5C	0.31	0.40	1.78	59.67	21.91	10.16	5.09	0.68	0.00	0.00	0.00
22 May 2009	FWA-5D	15.92	0.30	1.04	80.07	2.32	0.02	0.06	0.08	0.07	0.05	0.06
22 May 2009	FWA-5E	0.70	0.48	3.21	91.77	3.50	0.31	0.04	0.00	0.00	0.00	0.00
22 May 2009	FWA-5F	41.65	1.13	4.43	50.50	1.81	0.04	0.09	0.09	0.07	0.09	0.09
22 May 2009	FWA-5G	2.35	1.48	6.52	86.40	2.90	0.30	0.05	0.00	0.00	0.00	0.00
22 May 2009	FWA-5H	9.12	2.90	11.45	72.64	3.54	0.31	0.05	0.00	0.00	0.00	0.00
22 May 2009	FWA-5I	0.54	-0.06	-0.17	79.85	18.43	0.71	0.14	0.14	0.09	0.09	0.14
22 May 2009	FWA-5J	0.88	0.21	0.54	94.25	3.66	0.02	0.21	0.05	0.07	0.05	0.05
22 May 2009	FWB-5A	1.11	0.62	3.13	89.34	5.45	0.07	0.05	0.05	0.05	0.05	0.07
22 May 2009	FWB-5B	0.31	0.34	0.85	77.64	14.09	5.55	0.97	0.09	0.04	0.05	0.07
22 May 2009	FWB-5C	0.28	0.16	2.04	66.73	20.28	7.84	2.35	0.14	0.05	0.07	0.07
22 May 2009	FWB-5D	0.30	0.35	3.35	87.12	7.28	1.35	0.05	0.05	0.05	0.05	0.07
22 May 2009	FWB-5E	0.22	0.75	2.61	91.19	4.65	0.44	0.07	0.02	0.02	0.02	0.02
22 May 2009	FWB-5F	11.94	1.38	3.67	80.44	2.04	-0.03	0.10	0.14	0.05	0.05	0.10
22 May 2009	FWB-5G	5.47	2.28	10.80	78.28	2.83	0.14	0.02	0.04	0.05	0.05	0.05

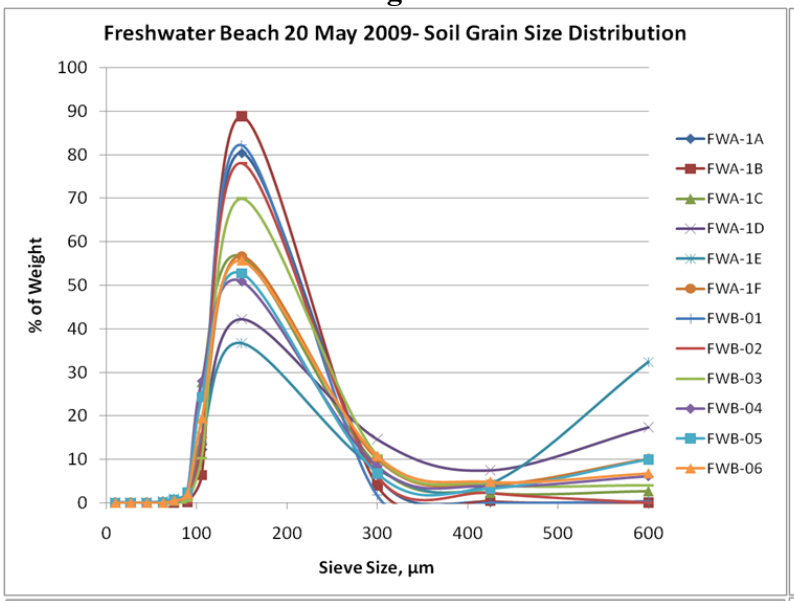
Table 8. 23 May 2009. Sabina Point Soil Grain Size Distribution.

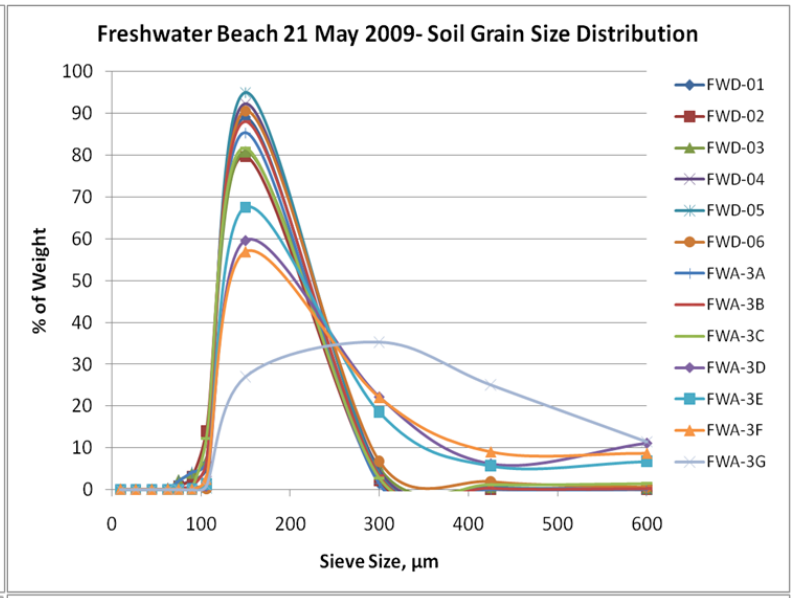
Date	Sample Name	Soil Grain Size Distribution (%)										
		600um	425um	300um	150um	106um	90um	75um	63um	45um	27um	pan
23 May 2009	SPB-1A	2.11	23.18	59.25	15.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23 May 2009	SPB-1B	59.22	31.54	8.69	0.50	0.05	0.00	0.00	0.00	0.00	0.00	0.00
23 May 2009	SPB-1C	51.32	34.45	12.43	1.63	0.06	0.08	0.00	0.00	0.00	0.00	0.00
23 May 2009	SPB-1D	57.32	31.48	10.06	1.09	0.03	0.03	0.00	0.00	0.00	0.00	0.00
23 May 2009	SPB-1E	21.64	48.91	27.82	1.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23 May 2009	SPB-1F	71.40	22.47	5.62	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23 May 2009	SPB-1G	21.79	42.70	29.99	5.41	0.08	0.03	0.00	0.00	0.00	0.00	0.00
23 May 2009	SPB-1H	35.27	34.03	27.02	3.54	0.08	0.03	0.03	0.00	0.00	0.00	0.00
23 May 2009	SPB-1I	27.07	28.70	33.29	10.05	0.82	0.05	0.00	0.00	0.02	0.00	0.00
23 May 2009	SPB-1J	33.71	9.72	30.82	22.06	2.55	0.47	0.21	0.13	0.11	0.02	0.02
23 May 2009	SPB-1K	54.95	5.78	24.08	12.84	1.81	0.27	0.12	0.08	0.00	0.00	0.00
23 May 2009	SPB-1L	13.03	15.79	50.35	18.85	1.86	0.12	0.02	0.00	0.00	0.00	0.00
23 May 2009	SPB-1M	12.78	9.94	36.93	26.93	6.86	1.63	1.25	1.07	0.41	0.11	0.17
23 May 2009	SPB-1N	11.74	5.29	40.22	33.89	6.29	0.83	0.58	0.51	0.14	0.09	0.12
23 May 2009	SPB-1O	1.84	2.15	30.56	53.96	10.15	0.89	0.29	0.13	0.00	0.00	0.00
23 May 2009	SPB-1P	3.36	2.84	30.27	53.66	8.64	1.00	0.24	0.00	0.00	0.00	0.00

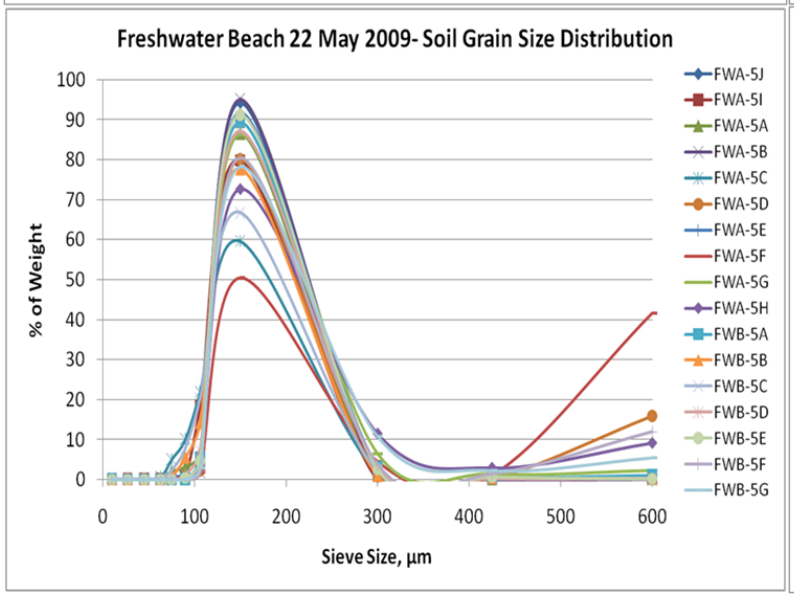
Table 9. 28 May 2009. Cape Clinton Pocket Beach Soil Grain Size Distribution.

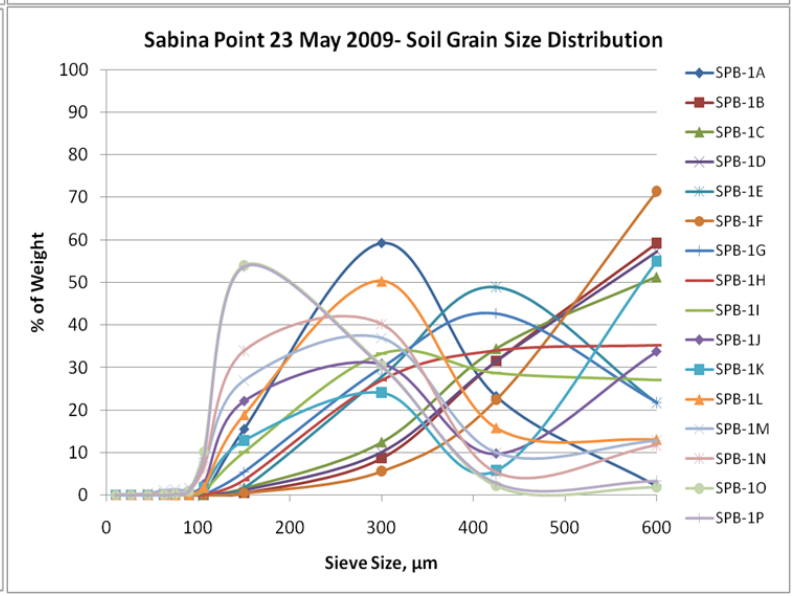
Date	Sample Name	Soil Grain Size Distribution (%)										
		600um	425um	300um	150um	106um	90um	75um	63um	45um	27um	pan
28 May 2009	PBJ-1A	0.54	0.57	1.28	53.07	38.91	3.86	0.97	0.28	0.20	0.20	0.18
28 May 2009	PBJ-1B	0.67	1.12	1.97	54.29	37.60	3.20	0.65	0.16	0.11	0.09	0.11
28 May 2009	PBJ-1C	0.94	0.27	0.55	37.73	55.59	3.87	0.65	0.12	0.07	0.07	0.10
28 May 2009	PBJ-1D	0.80	0.85	1.52	55.25	37.80	3.25	0.28	0.05	0.05	0.05	0.08
28 May 2009	PBJ-1E	0.50	0.26	1.15	31.41	60.74	4.34	1.23	0.13	0.07	0.05	0.08
28 May 2009	PBJ-1F	0.10	0.00	1.42	54.03	41.53	2.50	0.31	0.07	0.00	0.00	0.00
28 May 2009	PBJ-1G	0.24	0.05	0.13	27.97	65.94	4.39	0.98	0.29	0.00	0.00	0.00

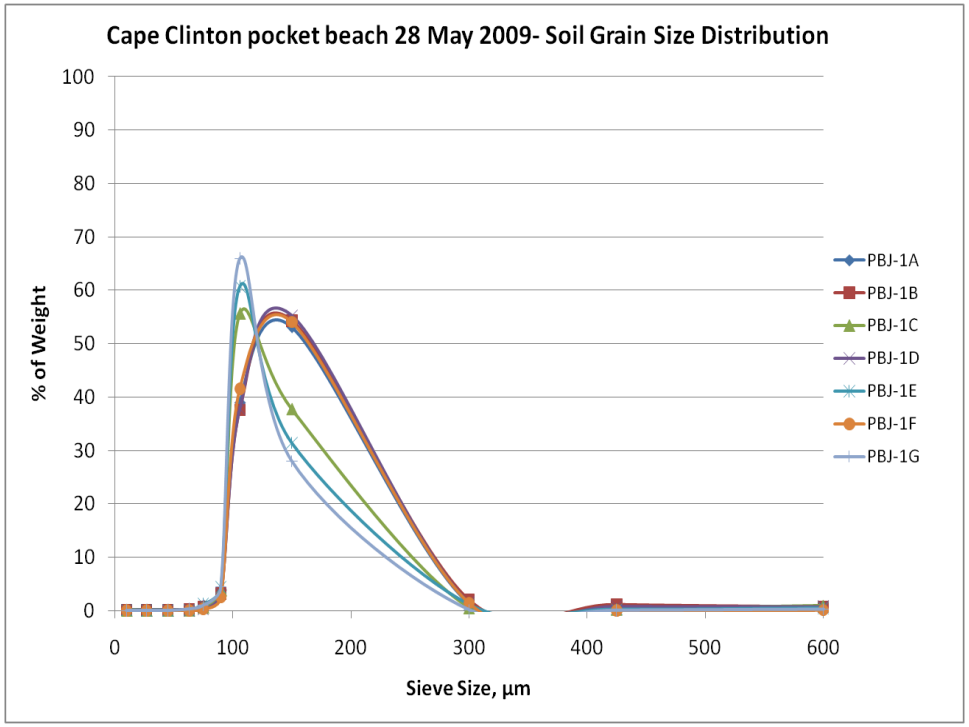
4.4 Soil Grain Size Distribution Figures










Cape Clinton pocket beach 28 May 2009- Soil Grain Size Distribution
% of Weight
Sieve Size, µm
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
PBJ-1A
PBJ-1B
PBJ-1C
PBJ-1D
PBJ-1E
PBJ-1F
PBJ-1G

APPENDIX I

Geotagged Photographs

1. Introduction

Geotagged photographs are photographs which have a global positioning system tag on the image, meaning that when the image is taken, the coordinates of the image are also recorded. These photographs provide a view of what the conditions were at the time the photograph was taken. Efforts were made to capture images of the beach from the perspective of what the amphibious assault personnel would see (images were taken perpendicular to the beach facing onshore). These pictures were taken from a vehicle at Freshwater beach on 19 May 2009 and 29 May 2009 and from a boat at Sabina Point on 23 May 2009. Figure 1 displays the location of all three datasets of imagery. These images are also provided in both the ArcGIS and ArcGIS Explorer versions of the geodatabase and have pop-up capability enabled (i.e. when the point in the shapefile is left-clicked, the image will display in the ArcMap or ArcGIS Explorer display window. Below Figure 1, Tables 1 through 3 lists the positioning, time, and filename of each photograph. The time indicated in these spreadsheets is in UTC time and to convert to Queensland time (EST), the addition of 10 hours is needed. Each picture is located at \TS09_GD\Attribute_Data\NOAA_Geo_Photos\ in the geodatabase.

2. Geotagged Photograph Locations

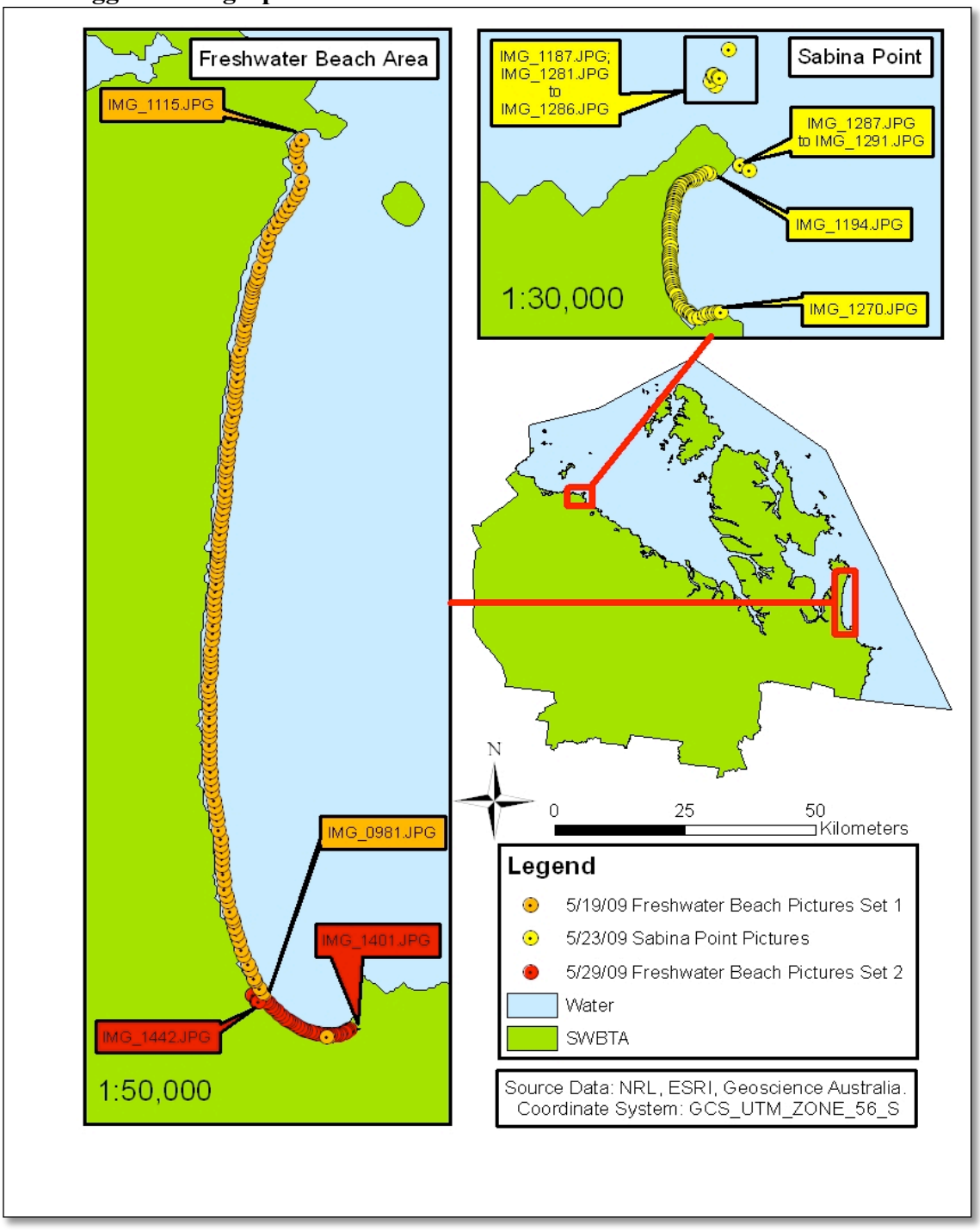


Figure 1.Geotagged photograph locations during TS09. Photographs were taken at Freshwater beach on 19 May 2009 and 29 May 2009. Sabina Point photographs were taken on 23 May 2009. Image names appear on the map. The order of these images is in sequential order with the exception of a few instances where non sequential groupings are called out (i.e. Sabina Point Insert).

3. Photograph Positional Data

Table 1. Geotagged photographs from Freshwater Beach, 19 May 2009. The table below presents the images that were taken on 19 May 2009. The latitude, longitude and altitude can be seen, as well as the time in UTC and the filename of each photograph. The tide condition during the capture of these photographs is approaching low tide. Low tide at Port Clinton Australia is 1:46 AM UTC for 19 May 2009.

Latitude	Longitude	Altitude	UTC Time (EST ADD 10 Hours)	Filename
-22.65027	150.78878	4.463256836	2009/05/19-00:17:00	IMG_0973.jpg
-22.64561	150.7819402	-0.343383789	2009/05/19-00:28:15	IMG_0981.jpg
-22.64514	150.7816124	-0.343383789	2009/05/19-00:28:21	IMG_0982.jpg
-22.64438	150.7811227	-0.343383789	2009/05/19-00:28:30	IMG_0983.jpg
-22.6441	150.7809771	-0.82409668	2009/05/19-00:28:33	IMG_0984.jpg
-22.64321	150.7805683	-0.82409668	2009/05/19-00:28:42	IMG_0985.jpg
-22.64268	150.780334	-1.3046875	2009/05/19-00:28:48	IMG_0986.jpg
-22.64167	150.7798884	-0.82409668	2009/05/19-00:29:00	IMG_0987.jpg
-22.6411	150.7796666	-0.82409668	2009/05/19-00:29:06	IMG_0988.jpg
-22.64017	150.779355	-0.82409668	2009/05/19-00:29:15	IMG_0989.jpg
-22.63951	150.7791387	-0.343383789	2009/05/19-00:29:21	IMG_0990.jpg
-22.63884	150.778946	0.137451172	2009/05/19-00:29:27	IMG_0991.jpg
-22.63816	150.7787635	0.618041992	2009/05/19-00:29:33	IMG_0992.jpg
-22.63781	150.7786746	0.618041992	2009/05/19-00:29:36	IMG_0993.jpg
-22.63712	150.7784814	1.098632813	2009/05/19-00:29:42	IMG_0994.jpg
-22.6361	150.7782214	1.098632813	2009/05/19-00:29:51	IMG_0995.jpg
-22.63544	150.7780767	1.098632813	2009/05/19-00:29:57	IMG_0996.jpg
-22.63482	150.7779448	1.098632813	2009/05/19-00:30:03	IMG_0997.jpg
-22.63389	150.7778414	0.618041992	2009/05/19-00:30:12	IMG_0998.jpg
-22.63322	150.7777738	0.137451172	2009/05/19-00:30:18	IMG_0999.jpg
-22.63223	150.7776971	0.137451172	2009/05/19-00:30:27	IMG_1000.jpg
-22.63156	150.7776882	0.618041992	2009/05/19-00:30:33	IMG_1001.jpg
-22.63089	150.7776956	0.618041992	2009/05/19-00:30:39	IMG_1002.jpg
-22.63021	150.7776335	0.618041992	2009/05/19-00:30:45	IMG_1003.jpg
-22.62955	150.7775413	0.618041992	2009/05/19-00:30:51	IMG_1004.jpg
-22.62854	150.7774086	0.137451172	2009/05/19-00:31:00	IMG_1005.jpg
-22.62753	150.7772534	0.137451172	2009/05/19-00:31:09	IMG_1006.jpg
-22.62686	150.7771444	0.618041992	2009/05/19-00:31:15	IMG_1007.jpg
-22.62618	150.7770154	0.618041992	2009/05/19-00:31:21	IMG_1008.jpg
-22.62552	150.776903	0.618041992	2009/05/19-00:31:27	IMG_1009.jpg
-22.62453	150.7767503	0.618041992	2009/05/19-00:31:36	IMG_1010.jpg
-22.62388	150.7766618	0.137451172	2009/05/19-00:31:42	IMG_1011.jpg
-22.62323	150.7765937	0.137451172	2009/05/19-00:31:48	IMG_1012.jpg
-22.62256	150.7765784	0.137451172	2009/05/19-00:31:54	IMG_1013.jpg
-22.62169	150.7765476	-0.343383789	2009/05/19-00:32:03	IMG_1014.jpg
-22.62108	150.7765366	-0.343383789	2009/05/19-00:32:09	IMG_1015.jpg
-22.62027	150.7765246	-0.82409668	2009/05/19-00:32:18	IMG_1016.jpg
-22.61975	150.7765317	-0.82409668	2009/05/19-00:32:24	IMG_1017.jpg
-22.61888	150.7765355	-0.82409668	2009/05/19-00:32:33	IMG_1018.jpg
-22.6183	150.7765321	-0.82409668	2009/05/19-00:32:39	IMG_1019.jpg
-22.61772	150.776557	-1.3046875	2009/05/19-00:32:45	IMG_1020.jpg
-22.61684	150.7765796	-1.78527832	2009/05/19-00:32:54	IMG_1021.jpg
-22.61598	150.7765305	-1.3046875	2009/05/19-00:33:03	IMG_1022.jpg
-22.61553	150.7765542	-1.3046875	2009/05/19-00:33:09	IMG_1023.jpg
-22.61474	150.7765462	-1.78527832	2009/05/19-00:33:18	IMG_1024.jpg
-22.61415	150.7765304	-1.78527832	2009/05/19-00:33:24	IMG_1025.jpg

Latitude	Longitude	Altitude	UTC Time (EST ADD 10 Hours)	Filename
-22.61353	150.7765456	-1.3046875	2009/05/19-00:33:30	IMG_1026.jpg
-22.61267	150.7766575	-1.3046875	2009/05/19-00:33:39	IMG_1027.jpg
-22.61215	150.7767154	-1.3046875	2009/05/19-00:33:45	IMG_1028.jpg
-22.61143	150.7767484	-1.3046875	2009/05/19-00:33:54	IMG_1029.jpg
-22.61092	150.7767613	-1.78527832	2009/05/19-00:34:00	IMG_1030.jpg
-22.61036	150.7768061	-1.78527832	2009/05/19-00:34:06	IMG_1031.jpg
-22.60982	150.7768633	-1.78527832	2009/05/19-00:34:12	IMG_1032.jpg
-22.6088	150.776935	-0.82409668	2009/05/19-00:34:27	IMG_1033.jpg
-22.60807	150.7770388	-0.82409668	2009/05/19-00:34:36	IMG_1034.jpg
-22.60728	150.7770996	-0.82409668	2009/05/19-00:34:45	IMG_1035.jpg
-22.60633	150.7771921	-0.82409668	2009/05/19-00:35:03	IMG_1036.jpg
-22.60565	150.7772329	-1.3046875	2009/05/19-00:35:12	IMG_1037.jpg
-22.60514	150.7772645	-1.78527832	2009/05/19-00:35:18	IMG_1038.jpg
-22.60438	150.777262	-2.265991211	2009/05/19-00:35:33	IMG_1039.jpg
-22.60371	150.7773962	-1.78527832	2009/05/19-00:35:42	IMG_1040.jpg
-22.60286	150.7774785	-1.78527832	2009/05/19-00:35:51	IMG_1041.jpg
-22.60216	150.7775651	-1.78527832	2009/05/19-00:36:00	IMG_1042.jpg
-22.60166	150.7776064	-1.3046875	2009/05/19-00:36:09	IMG_1043.jpg
-22.60111	150.7776571	-1.78527832	2009/05/19-00:36:15	IMG_1044.jpg
-22.60057	150.7776968	-2.265991211	2009/05/19-00:36:21	IMG_1045.jpg
-22.5999	150.7778429	-2.265991211	2009/05/19-00:36:30	IMG_1046.jpg
-22.59958	150.7778712	-2.265991211	2009/05/19-00:36:36	IMG_1047.jpg
-22.59888	150.7778062	-1.3046875	2009/05/19-00:36:45	IMG_1048.jpg
-22.59829	150.7778417	-1.3046875	2009/05/19-00:36:51	IMG_1049.jpg
-22.59771	150.7780251	-1.3046875	2009/05/19-00:36:57	IMG_1050.jpg
-22.597	150.7781566	-1.3046875	2009/05/19-00:37:06	IMG_1051.jpg
-22.59627	150.7781563	-0.82409668	2009/05/19-00:37:18	IMG_1052.jpg
-22.59575	150.778225	-0.82409668	2009/05/19-00:37:24	IMG_1053.jpg
-22.59497	150.7783998	-0.82409668	2009/05/19-00:37:33	IMG_1054.jpg
-22.59433	150.7784944	-1.3046875	2009/05/19-00:37:42	IMG_1055.jpg
-22.59385	150.7785276	-0.82409668	2009/05/19-00:37:48	IMG_1056.jpg
-22.59313	150.7786296	-1.3046875	2009/05/19-00:37:57	IMG_1057.jpg
-22.59236	150.7786454	-0.82409668	2009/05/19-00:38:06	IMG_1058.jpg
-22.59185	150.7787021	-0.82409668	2009/05/19-00:38:12	IMG_1059.jpg
-22.59116	150.7787492	-0.82409668	2009/05/19-00:38:21	IMG_1060.jpg
-22.59072	150.7788244	-1.3046875	2009/05/19-00:38:27	IMG_1061.jpg
-22.58994	150.7789496	-0.82409668	2009/05/19-00:38:36	IMG_1062.jpg
-22.58946	150.7790165	-0.82409668	2009/05/19-00:38:42	IMG_1063.jpg
-22.58888	150.779052	-0.82409668	2009/05/19-00:38:51	IMG_1064.jpg
-22.58819	150.779188	-0.343383789	2009/05/19-00:39:00	IMG_1065.jpg
-22.58731	150.779345	-0.82409668	2009/05/19-00:39:12	IMG_1066.jpg
-22.58648	150.7793216	0.137451172	2009/05/19-00:39:27	IMG_1067.jpg
-22.58592	150.7794504	-0.343383789	2009/05/19-00:39:36	IMG_1068.jpg
-22.58548	150.7795584	-0.343383789	2009/05/19-00:39:42	IMG_1069.jpg
-22.58472	150.7797626	-0.82409668	2009/05/19-00:39:54	IMG_1070.jpg
-22.58402	150.7797813	-0.343383789	2009/05/19-00:40:03	IMG_1071.jpg
-22.58342	150.7796993	1.098632813	2009/05/19-00:40:12	IMG_1072.jpg
-22.58285	150.7799025	1.098632813	2009/05/19-00:40:21	IMG_1073.jpg
-22.58236	150.7799813	1.098632813	2009/05/19-00:40:27	IMG_1074.jpg

Latitude	Longitude	Altitude	UTC Time (EST ADD 10 Hours)	Filename
-22.58184	150.780066	0.618041992	2009/05/19-00:40:33	IMG_1075.jpg
-22.58106	150.7801709	-0.343383789	2009/05/19-00:40:42	IMG_1076.jpg
-22.58025	150.7802388	-0.82409668	2009/05/19-00:40:51	IMG_1077.jpg
-22.57969	150.7802804	-0.82409668	2009/05/19-00:40:57	IMG_1078.jpg
-22.57916	150.7803178	-1.3046875	2009/05/19-00:41:03	IMG_1079.jpg
-22.57849	150.7805354	-1.3046875	2009/05/19-00:41:12	IMG_1080.jpg
-22.57754	150.780829	-2.265991211	2009/05/19-00:41:24	IMG_1081.jpg
-22.57704	150.7809042	-2.265991211	2009/05/19-00:41:30	IMG_1082.jpg
-22.57657	150.780947	-2.746704102	2009/05/19-00:41:36	IMG_1083.jpg
-22.57605	150.7810091	-2.265991211	2009/05/19-00:41:42	IMG_1084.jpg
-22.57525	150.7812996	-2.746704102	2009/05/19-00:41:51	IMG_1085.jpg
-22.57491	150.7814298	-2.746704102	2009/05/19-00:41:57	IMG_1086.jpg
-22.57449	150.7814239	-1.78527832	2009/05/19-00:42:06	IMG_1087.jpg
-22.57407	150.7815668	-1.3046875	2009/05/19-00:42:12	IMG_1088.jpg
-22.57359	150.7817063	-1.3046875	2009/05/19-00:42:18	IMG_1089.jpg
-22.57307	150.781818	-1.78527832	2009/05/19-00:42:24	IMG_1090.jpg
-22.57252	150.7819464	-1.78527832	2009/05/19-00:42:30	IMG_1091.jpg
-22.57211	150.7820271	-1.78527832	2009/05/19-00:42:36	IMG_1092.jpg
-22.57181	150.7820984	-1.3046875	2009/05/19-00:42:42	IMG_1093.jpg
-22.57145	150.7823049	-1.3046875	2009/05/19-00:42:48	IMG_1094.jpg
-22.57107	150.7824498	-1.3046875	2009/05/19-00:42:54	IMG_1095.jpg
-22.57043	150.7826146	-1.3046875	2009/05/19-00:43:03	IMG_1096.jpg
-22.56997	150.7827379	-1.3046875	2009/05/19-00:43:09	IMG_1097.jpg
-22.5688	150.7832212	0.137451172	2009/05/19-00:43:54	IMG_1098.jpg
-22.56812	150.7834389	0.137451172	2009/05/19-00:44:03	IMG_1099.jpg
-22.56749	150.7836975	0.137451172	2009/05/19-00:44:12	IMG_1100.jpg
-22.56659	150.7837451	1.579345703	2009/05/19-00:44:27	IMG_1101.jpg
-22.56582	150.784477	1.098632813	2009/05/19-00:44:45	IMG_1102.jpg
-22.56522	150.7848398	1.579345703	2009/05/19-00:44:54	IMG_1103.jpg
-22.56459	150.7853409	1.579345703	2009/05/19-00:45:03	IMG_1104.jpg
-22.56409	150.7856823	1.098632813	2009/05/19-00:45:09	IMG_1105.jpg
-22.56363	150.7860428	1.098632813	2009/05/19-00:45:15	IMG_1106.jpg
-22.56289	150.7866011	0.618041992	2009/05/19-00:45:24	IMG_1107.jpg
-22.56239	150.7869466	-0.343383789	2009/05/19-00:45:30	IMG_1108.jpg
-22.56189	150.7871724	-0.343383789	2009/05/19-00:45:36	IMG_1109.jpg
-22.56104	150.7874588	-0.82409668	2009/05/19-00:45:45	IMG_1110.jpg
-22.55957	150.7872344	1.098632813	2009/05/19-00:46:00	IMG_1111.jpg
-22.55858	150.7868807	0.618041992	2009/05/19-00:46:12	IMG_1112.jpg
-22.5579	150.7868763	1.579345703	2009/05/19-00:46:21	IMG_1113.jpg
-22.55729	150.7870908	1.579345703	2009/05/19-00:46:30	IMG_1114.jpg
-22.55668	150.7874804	0.618041992	2009/05/19-00:46:42	IMG_1115.jpg

Table 2. Geotagged photographs from Sabina Point, 23 May 2009. The table below presents the images that were taken on 23 May 2009. The latitude, longitude and altitude can be seen, as well as the time in UTC and the filename of each photograph. The tide condition during the capture of these photographs is approaching low tide. Low tide for Port Clinton, Australia for 23 May 2009 is 4:41AM UTC.

Latitude	Longitude	Altitude	UTC Time (EST ADD 10 Hours)	Filename
-22.3917	150.3029	10.71179	2009/05/23-00:39:35	IMG_1187.jpg
-22.3994	150.3015	3.02124	2009/05/23-00:59:03	IMG_1194.jpg
-22.3994	150.3012	1.579346	2009/05/23-00:59:30	IMG_1195.jpg
-22.3995	150.3009	3.982666	2009/05/23-01:00:03	IMG_1196.jpg
-22.3996	150.3007	4.943848	2009/05/23-01:00:24	IMG_1197.jpg
-22.3998	150.3005	4.463257	2009/05/23-01:00:45	IMG_1198.jpg
-22.3999	150.3004	3.501953	2009/05/23-01:01:03	IMG_1199.jpg
-22.3999	150.3002	4.463257	2009/05/23-01:01:21	IMG_1200.jpg
-22.3999	150.3	3.02124	2009/05/23-01:01:39	IMG_1201.jpg
-22.4	150.2999	2.540649	2009/05/23-01:01:51	IMG_1202.jpg
-22.4	150.2998	2.540649	2009/05/23-01:02:00	IMG_1203.jpg
-22.4001	150.2997	2.540649	2009/05/23-01:02:09	IMG_1204.jpg
-22.4002	150.2996	2.540649	2009/05/23-01:02:27	IMG_1205.jpg
-22.4002	150.2995	2.060059	2009/05/23-01:02:39	IMG_1206.jpg
-22.4004	150.2994	3.501953	2009/05/23-01:03:06	IMG_1207.jpg
-22.4005	150.2993	2.540649	2009/05/23-01:03:22	IMG_1208.jpg
-22.4007	150.2992	1.098633	2009/05/23-01:03:37	IMG_1209.jpg
-22.4007	150.2993	1.098633	2009/05/23-01:05:13	IMG_1210.jpg
-22.4008	150.2992	0.137451	2009/05/23-01:05:34	IMG_1211.jpg
-22.4009	150.2992	0.137451	2009/05/23-01:05:49	IMG_1212.jpg
-22.4011	150.2991	-0.8241	2009/05/23-01:06:01	IMG_1213.jpg
-22.4011	150.2991	-1.78528	2009/05/23-01:06:10	IMG_1214.jpg
-22.4013	150.2991	-0.8241	2009/05/23-01:06:25	IMG_1215.jpg
-22.4014	150.2991	1.098633	2009/05/23-01:06:40	IMG_1216.jpg
-22.4015	150.2991	1.098633	2009/05/23-01:06:49	IMG_1217.jpg
-22.4016	150.299	0.137451	2009/05/23-01:07:04	IMG_1218.jpg
-22.4018	150.299	3.02124	2009/05/23-01:07:25	IMG_1219.jpg
-22.4019	150.299	1.579346	2009/05/23-01:07:43	IMG_1220.jpg
-22.4021	150.299	1.579346	2009/05/23-01:08:04	IMG_1221.jpg
-22.4023	150.2989	0.618042	2009/05/23-01:08:25	IMG_1222.jpg
-22.4024	150.2988	2.060059	2009/05/23-01:08:40	IMG_1223.jpg
-22.4026	150.2988	1.098633	2009/05/23-01:08:55	IMG_1224.jpg
-22.4027	150.2988	2.060059	2009/05/23-01:09:17	IMG_1225.jpg
-22.4029	150.2988	0.137451	2009/05/23-01:09:39	IMG_1226.jpg
-22.4031	150.2988	1.579346	2009/05/23-01:09:57	IMG_1227.jpg
-22.4033	150.2988	2.540649	2009/05/23-01:10:12	IMG_1228.jpg
-22.4034	150.2988	1.579346	2009/05/23-01:10:27	IMG_1229.jpg
-22.4036	150.2988	0.137451	2009/05/23-01:10:48	IMG_1230.jpg
-22.4038	150.2988	0.618042	2009/05/23-01:11:09	IMG_1231.jpg
-22.404	150.2988	0.618042	2009/05/23-01:11:33	IMG_1232.jpg
-22.4042	150.2988	0.618042	2009/05/23-01:12:03	IMG_1233.jpg
-22.4044	150.2988	-0.34338	2009/05/23-01:12:21	IMG_1234.jpg
-22.4046	150.2988	-0.8241	2009/05/23-01:12:36	IMG_1235.jpg
-22.4047	150.2988	-0.34338	2009/05/23-01:12:54	IMG_1236.jpg
-22.4048	150.2988	0.618042	2009/05/23-01:13:06	IMG_1237.jpg

Latitude	Longitude	Altitude	UTC Time (EST ADD 10 Hours)	Filename
-22.405	150.2988	0.137451	2009/05/23-01:13:21	IMG_1238.jpg
-22.4052	150.2988	-0.8241	2009/05/23-01:13:45	IMG_1239.jpg
-22.4053	150.2988	0.137451	2009/05/23-01:13:57	IMG_1240.jpg
-22.4055	150.2988	0.137451	2009/05/23-01:14:18	IMG_1241.jpg
-22.4057	150.2988	0.137451	2009/05/23-01:14:36	IMG_1242.jpg
-22.4058	150.2988	0.137451	2009/05/23-01:14:48	IMG_1243.jpg
-22.4059	150.2988	0.618042	2009/05/23-01:15:00	IMG_1244.jpg
-22.406	150.2989	-0.34338	2009/05/23-01:15:12	IMG_1245.jpg
-22.4062	150.2989	0.618042	2009/05/23-01:15:24	IMG_1246.jpg
-22.4063	150.2989	-0.34338	2009/05/23-01:15:42	IMG_1247.jpg
-22.4065	150.299	-0.34338	2009/05/23-01:15:57	IMG_1248.jpg
-22.4067	150.299	0.137451	2009/05/23-01:16:15	IMG_1249.jpg
-22.4068	150.299	-1.78528	2009/05/23-01:16:30	IMG_1250.jpg
-22.4069	150.2991	-0.8241	2009/05/23-01:16:42	IMG_1251.jpg
-22.407	150.2991	0.137451	2009/05/23-01:16:54	IMG_1252.jpg
-22.4073	150.2993	-0.34338	2009/05/23-01:17:30	IMG_1253.jpg
-22.4074	150.2993	-1.30469	2009/05/23-01:17:42	IMG_1254.jpg
-22.4076	150.2994	-1.30469	2009/05/23-01:18:00	IMG_1255.jpg
-22.4077	150.2994	-1.30469	2009/05/23-01:18:15	IMG_1256.jpg
-22.4078	150.2995	-0.34338	2009/05/23-01:18:33	IMG_1257.jpg
-22.4079	150.2997	-2.26599	2009/05/23-01:18:51	IMG_1258.jpg
-22.4081	150.2999	-2.26599	2009/05/23-01:19:09	IMG_1259.jpg
-22.4082	150.3	-0.8241	2009/05/23-01:19:30	IMG_1260.jpg
-22.4083	150.3001	-0.34338	2009/05/23-01:19:42	IMG_1261.jpg
-22.4084	150.3002	-0.34338	2009/05/23-01:19:57	IMG_1262.jpg
-22.4085	150.3003	-0.8241	2009/05/23-01:20:12	IMG_1263.jpg
-22.4085	150.3006	-0.8241	2009/05/23-01:20:36	IMG_1264.jpg
-22.4083	150.301	4.463257	2009/05/23-01:21:12	IMG_1265.jpg
-22.4082	150.3012	3.501953	2009/05/23-01:21:30	IMG_1266.jpg
-22.4082	150.3015	2.540649	2009/05/23-01:21:51	IMG_1267.jpg
-22.4082	150.3017	2.060059	2009/05/23-01:22:06	IMG_1268.jpg
-22.4082	150.3019	0.618042	2009/05/23-01:22:21	IMG_1269.jpg
-22.4082	150.302	0.137451	2009/05/23-01:22:30	IMG_1270.jpg
-22.3939	150.3019	0.618042	2009/05/23-03:56:26	IMG_1281.jpg
-22.3937	150.3016	-1.78528	2009/05/23-03:57:14	IMG_1282.jpg
-22.3933	150.3018	-3.22729	2009/05/23-03:58:32	IMG_1283.jpg
-22.3933	150.3019	-3.70789	2009/05/23-03:58:41	IMG_1284.jpg
-22.3934	150.3021	-3.70789	2009/05/23-03:59:05	IMG_1285.jpg
-22.3935	150.3022	-2.7467	2009/05/23-03:59:17	IMG_1286.jpg
-22.399	150.3035	-3.70789	2009/05/23-04:14:23	IMG_1287.jpg
-22.399	150.3034	-1.78528	2009/05/23-04:14:29	IMG_1288.jpg
-22.3993	150.3041	-3.22729	2009/05/23-04:16:23	IMG_1291.jpg

Table 3. Geotagged photographs from Freshwater Beach, 29 May 2009. The table below presents the images that were taken on 29 May 2009. The latitude, longitude and altitude can be seen, as well as the time in UTC and the filename of each photograph. The tide condition during the capture of these photographs is approaching high tide. High tide for Port Clinton, Australia is 3:51AM UTC.

Latitude	Longitude	Altitude	UTC Time (EST ADD 10 Hours)	Filename
-22.6496	150.7913	-1.30469	2009/05/29-01:12:02	IMG_1401.jpg
-22.6497	150.791	-0.8241	2009/05/29-01:12:11	IMG_1402.jpg
-22.6498	150.7908	-0.8241	2009/05/29-01:12:19	IMG_1403.jpg
-22.6499	150.7907	-0.8241	2009/05/29-01:12:26	IMG_1404.jpg
-22.65	150.7903	-0.8241	2009/05/29-01:12:44	IMG_1405.jpg
-22.6501	150.7901	-0.8241	2009/05/29-01:12:50	IMG_1406.jpg
-22.6501	150.7898	0.137451	2009/05/29-01:13:02	IMG_1407.jpg
-22.6501	150.7895	1.098633	2009/05/29-01:13:11	IMG_1408.jpg
-22.6501	150.7892	2.060059	2009/05/29-01:13:20	IMG_1409.jpg
-22.6501	150.7889	2.540649	2009/05/29-01:13:26	IMG_1410.jpg
-22.6501	150.7886	2.540649	2009/05/29-01:13:32	IMG_1411.jpg
-22.6501	150.7884	2.540649	2009/05/29-01:13:38	IMG_1412.jpg
-22.65	150.788	1.579346	2009/05/29-01:13:47	IMG_1413.jpg
-22.6499	150.7877	1.098633	2009/05/29-01:13:53	IMG_1414.jpg
-22.6498	150.7873	1.098633	2009/05/29-01:14:02	IMG_1415.jpg
-22.6497	150.7869	1.098633	2009/05/29-01:14:11	IMG_1416.jpg
-22.6496	150.7865	0.618042	2009/05/29-01:14:20	IMG_1417.jpg
-22.6495	150.7862	0.618042	2009/05/29-01:14:26	IMG_1418.jpg
-22.6493	150.7859	0.618042	2009/05/29-01:14:32	IMG_1419.jpg
-22.6492	150.7856	1.098633	2009/05/29-01:14:41	IMG_1420.jpg
-22.6489	150.7852	0.137451	2009/05/29-01:14:50	IMG_1421.jpg
-22.6487	150.7848	0.137451	2009/05/29-01:14:59	IMG_1422.jpg
-22.6485	150.7845	0.137451	2009/05/29-01:15:05	IMG_1423.jpg
-22.6484	150.7843	0.618042	2009/05/29-01:15:11	IMG_1424.jpg
-22.6481	150.784	2.060059	2009/05/29-01:15:20	IMG_1425.jpg
-22.6478	150.7836	2.060059	2009/05/29-01:15:29	IMG_1426.jpg
-22.6475	150.7833	2.060059	2009/05/29-01:15:38	IMG_1427.jpg
-22.6472	150.783	2.540649	2009/05/29-01:15:47	IMG_1428.jpg
-22.647	150.7828	2.060059	2009/05/29-01:15:53	IMG_1429.jpg
-22.6467	150.7825	2.060059	2009/05/29-01:16:02	IMG_1430.jpg
-22.6465	150.7823	1.579346	2009/05/29-01:16:08	IMG_1431.jpg
-22.6462	150.782	1.579346	2009/05/29-01:16:17	IMG_1432.jpg
-22.6459	150.7818	1.098633	2009/05/29-01:16:23	IMG_1433.jpg
-22.6457	150.7816	1.098633	2009/05/29-01:16:29	IMG_1434.jpg
-22.6454	150.7814	1.579346	2009/05/29-01:16:38	IMG_1435.jpg
-22.6459	150.7808	5.424561	2009/05/29-01:35:51	IMG_1436.jpg
-22.6459	150.7808	5.905273	2009/05/29-01:36:06	IMG_1437.jpg
-22.6459	150.7808	3.02124	2009/05/29-01:36:30	IMG_1438.jpg
-22.6465	150.7813	4.463257	2009/05/29-01:38:24	IMG_1439.jpg
-22.6465	150.7813	6.385864	2009/05/29-01:38:36	IMG_1440.jpg
-22.6466	150.7813	-0.8241	2009/05/29-01:38:54	IMG_1441.jpg
-22.6466	150.7814	9.269897	2009/05/29-01:39:27	IMG_1442.jpg

APPENDIX J

NOAA Survey Data

---

1. Introduction

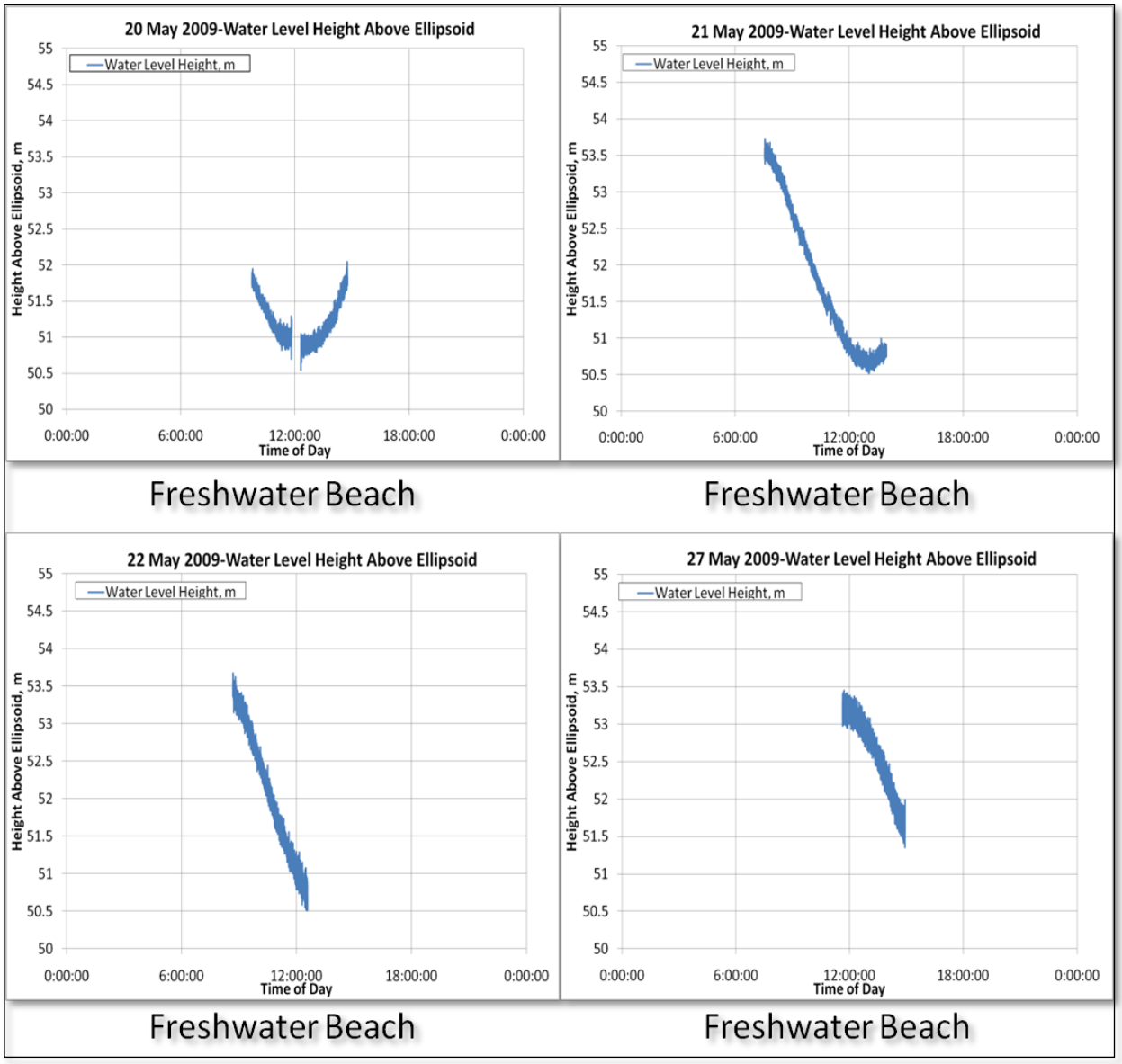
1.1. Water Level Buoy Data

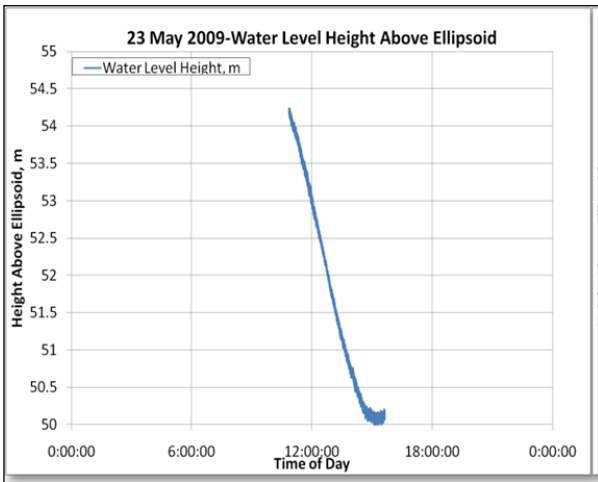
A water level buoy instrument was developed in order to accurately record water level height. The results were then used to validate sounding data and results from HSI developed models. The buoy was composed of a floating frame with a GPS unit attached above the frame. A photograph of the buoy can be seen in the main body section (Figure 12). In Section 2, plots of the water level data can be seen. The data that were collected contained the position of the buoy, the time of data collection, and height above the ellipsoid. The frequency of data collection is one sample per second. The plots describe the water level heights at Freshwater Beach on 20-23 May and 27 May 2009; Sabina Point on 23 May 2009; Southern Arm Estuary on 25 May 2009; and at the pocket beach at Cape Clinton on 28 May 2009. The data presented in these figures was divided into subsets in order to excise the actions of entry and exit from the beach to the water. The height levels were recorded in height above ellipsoid (WGS_84).

1.2. Kinematic GPS Survey Data

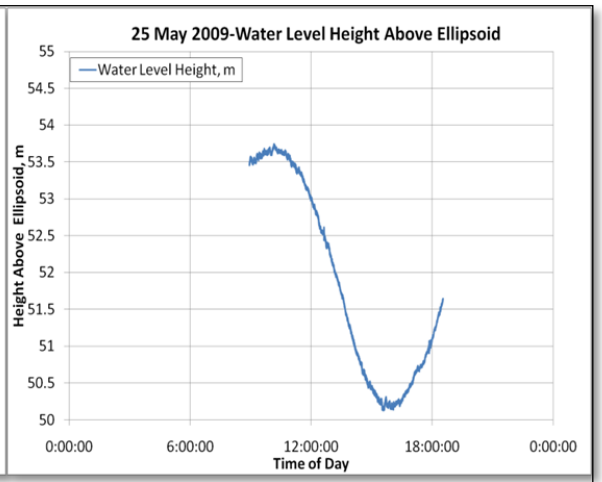
Team members from NOAA performed a geographic survey of the shore regions of Freshwater Beach, Sabina Point, and the pocket beach at Cape Clinton through the use of a post-processed kinematic GPS. Each position was recorded from the GPS receiver, with the positioning being based on the GCS WGS 1984 coordinate system. The GPS base station provided differential correction capabilities with the kinematic units. The data from the kinematic GPS were provided in shapefile format. This data were used to analyze the accuracy of developed bathymetric models and other products. Section 3 lists the available shapefiles developed by NOAA.

2. Water Level Buoy Graphs

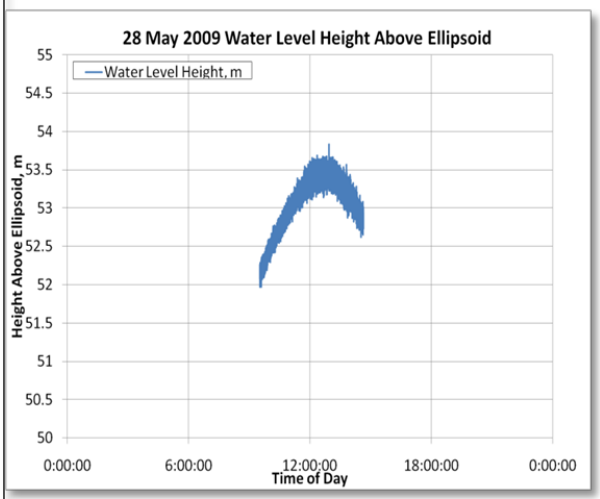




Sabina Point



Southern Arm Estuary



Cape Clinton Pocket Beach

3. Kinematic GPS Survey Data Shapefiles

File Name	Date of Capture	Geographic Location	File Size, KB
143_spb_wheel_kin.dbf	23 May 2009	Sabina Point	3460
143_spb_wheel_kin.prj	23 May 2009	Sabina Point	1
143_spb_wheel_kin.shp	23 May 2009	Sabina Point	192
143_spb_wheel_kin.shp.xml	23 May 2009	Sabina Point	11
143_spb_wheel_kin.shx	23 May 2009	Sabina Point	55
fwb_kin_merge.dbf	Multiple	Freshwater Beach	7437
fwb_kin_merge.prj	Multiple	Freshwater Beach	1
fwb_kin_merge.sbn	Multiple	Freshwater Beach	765
fwb_kin_merge.sbx	Multiple	Freshwater Beach	19
fwb_kin_merge.shp	Multiple	Freshwater Beach	3409
fwb_kin_merge.shp.xml	Multiple	Freshwater Beach	10
fwb_kin_merge.shx	Multiple	Freshwater Beach	620
tarp_gcps.dbf	22 May 2009	Freshwater Beach	1
tarp_gcps.evf	22 May 2009	Freshwater Beach	2
tarp_gcps.prj	22 May 2009	Freshwater Beach	1
tarp_gcps.shp	22 May 2009	Freshwater Beach	1
tarp_gcps.shx	22 May 2009	Freshwater Beach	8
tarp_gcps.shp.xml	22 May 2009	Freshwater Beach	1

Location	GPS Data Points
Sabina Point	6986
Freshwater Beach	79,322
Tarps at Freshwater Beach	19